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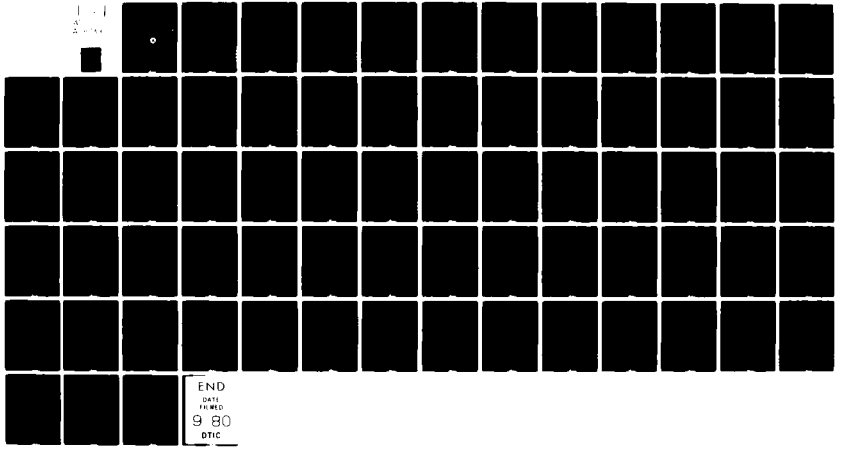

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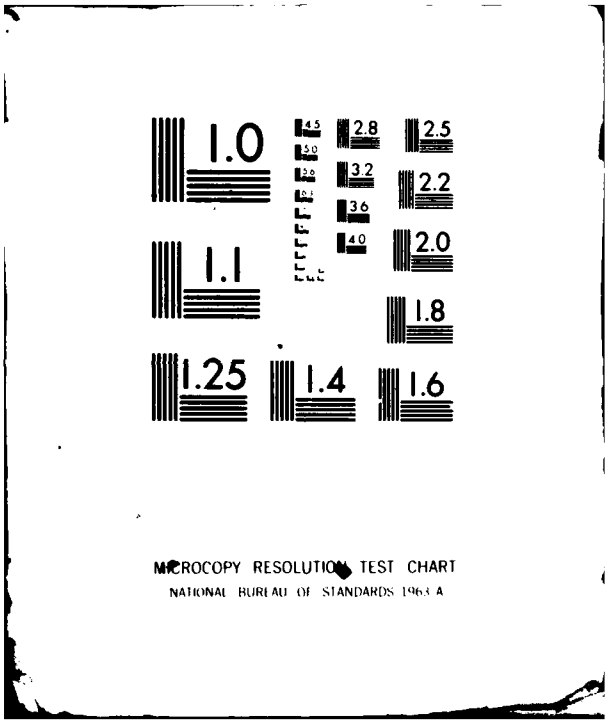
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Report No. FAA-ASP-80-6

LEVEL II

12

FAA COMMUNICATIONS COST MODEL USER'S GUIDE (REVISED)

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I. Gershkoff

APRIL 1980

Prepared for
DEPARTMENT OF TRANSPORTATION
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16. Abstract

The FAA Communications Cost Model User's Guide provides information regarding applications, requirements, and operation of the model, describes user input data and procedures for setting up a run, and gives a sample problem showing how each data card is set up. Appendixes provide facilities and equipment (F&E) and operations and maintenance (O&M) parameters assumed in the model and describe each output report. The documents related to this study are Report No. FAA-ASP-80-7, "FAA Communications Cost Model Program Documentation (Revised)," and Report No. FAA-ASP-80-8, "Impact of Selected FAA Programs on Switched and Nonswitched Network Costs."

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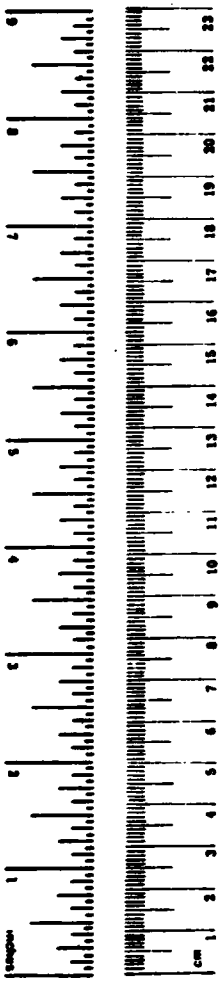
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

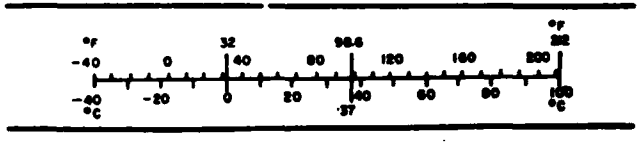
Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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SECTION ONE

INTRODUCTION

The FAA Communications Cost Model User's Guide is divided into three sections. Section One provides background information on the model in terms of applications, requirements, and operation. Section Two describes all user input data and provides instructions for setting up a run. Section Three describes a sample problem showing how each data card is set up. Two appendixes provide a quick reference for nominal facilities and equipment (F&E) and operation and maintenance (O&M) parameters assumed in the model. A third appendix describes each output report to assist the user in interpreting data formats. The fourth appendix is a glossary of facility codes used in this report.

1.1 GENERAL APPLICABILITY

The FAA Communications Model is designed to fulfill a number of general requirements discussed in the following subsections.

1.1.1 High-Level User Input

User inputs to the model are in terms of broad, operationally defined requirements that do not require detailed user knowledge of communications system design. Precise characteristics of new facilities and actual geographic locations are not needed. The advantage of this approach is that the model will be useful to a broad spectrum of users and not just communications engineers.

1.1.2 Long-Term Macro Analysis

The model is primarily intended to address long-term macro-level communications issues as opposed to short-term micro-level issues. The smallest period the model is capable of analyzing is one year. It computes total FAA communications requirements for the 48 contiguous states as well as Alaska, Hawaii, and Puerto Rico. The forecast algorithms employed permit analyses covering any period from 1979 through 2008.

1.1.3 Accuracy

The model is designed to provide order-of-magnitude costs as opposed to specific costs on which a detailed budget can be based. The primary quantity

of interest is the relative cost of one communications system when compared with an alternative system. However, spot comparisons with actual FY 1979 FAA cost data indicate that actual costs are well within 10 percent of the computed values.

1.1.4 Limitations

The model does not currently include FAA facilities that do not have communications functions; however, sufficient space exists to add 30 additional facilities beyond the 64 currently included. Of these 64 facilities, many serve functions that are considered partially communications. Appendixes A and B reflect estimated percentages for each facility type. The correct percentage will vary somewhat depending on the particular program being evaluated and the context in which the evaluation is performed.

The model does not include the cost of operations personnel nor the cost of administrative communications circuits.

1.2 OPERATING CHARACTERISTICS

The following subsections describe salient operational requirements of the model.

1.2.1 FORTRAN IV

The model was developed and coded in FORTRAN IV-G for the IBM 360/65 computer at the Transportation Computer Center.

1.2.2 Remote Job Entry

The model is designed for batch operation from a remote card terminal and accepts user inputs in punched card format.

1.2.3 Core Requirements

The source program consists of about 1000 cards. Memory requirements on an IBM computer are 56K words. Approximately 15K words of additional core are required to compile and execute the program. This figure will vary depending on the operating system.

1.2.4 Execution Time

Execution time varies depending on processor load during the program run, the period of the analysis, and the reports desired. Typical execution times range from 30 seconds to 1 minute. Compilation time is primarily dependent on processor load and may range from 2 to 5 minutes.

1.2.5 Documentation

The model is self-documenting in the sense that comment cards have been used liberally throughout to mark the various routines. Much of the

information generated by the model is documented by the various output reports provided.

For the model's mathematical formulation, associated computer programming, and logic flow, the user should refer to the companion report, "Program Documentation for the FAA Communications Cost Model." For a discussion of actual applications and analyses of results, the user should read the reports entitled "Evaluation of Selected Communications Systems Alternatives" and "Cost Analysis of Selected FAA Switches Network Configurations."

1.3 MODEL OPERATION

There are frequently several ways to program an alternative to be evaluated by the model. Experience will be the best guide in each case. Lacking experience, however, the first-time user can begin by considering the overall operation of the model.

Figure 1-1 illustrates the basic elements of the model structure. User inputs are interpreted by the model and cause appropriate changes in the internal data base. A series of algorithms is used to forecast growth in five major facility types. These are sectors, centers, towers, terminal radars, and flight service stations; collectively these are referred to as operational units. Requirements for all other facilities, such as ILS, RCAG, etc., are dependent upon the growth of these five operational units and traffic forecasts. Once facility requirements are established, various modules compute costs for facilities, maintenance, circuits, and leased equipment. Inflation and discounting are applied to the various costs in the output module.

Of primary concern to the user is the input module that interprets data from punched cards. The format of these cards is described in detail in Section Two. The types of changes that can be made to the data base by means of punched cards are described in Table 1-1.

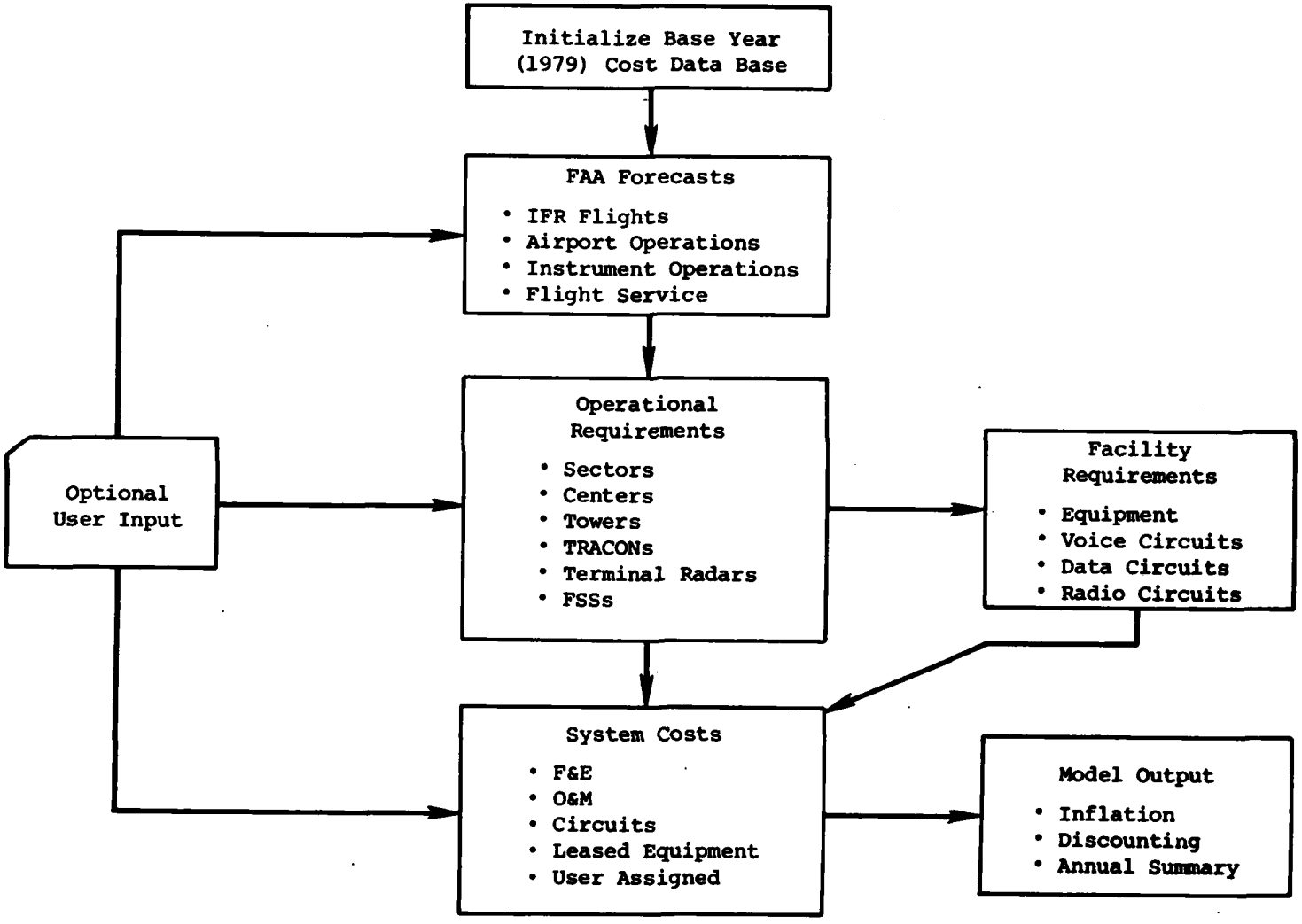


Figure 1-1. COMMUNICATIONS MODEL OPERATION

Table 1-1. COMMUNICATIONS MODEL INPUTS

Card Type	Function	Required	Descriptions
ø	Program Set-Up	Yes	Job control data and run description
1	Facilities and Equipment	No	Defines F&E costs, quantities, and communications percentages
2	Operations and Maintenance	No	Defines O&M costs and communications percentages
3	Not Used	--	---
4	Transition	No	Defines implementation dates and conversion rates for F&E and O&M
5	Tariffs	No	Defines cost per mile and termination charges for as many as nine tariffs
6	User Assigned Costs	No	Defines fixed user costs for each year. These costs are not manipulated by model.
7	Inflation and Growth	Yes	Defines inflation factors; discount; productivity factors; traffic growth for IFR, instrument operations, airport operations; and flight services
8	Circuits	No	Defines average length, quantity, utilization, tariff schedule, and switching for the different circuit types
9	Reports	Yes	Defines analysis period and desired reports

SECTION TWO

MODEL INPUTS

The FAA communications model contains an extensive data base consisting of equipment quantities, circuit characteristics, cost factors, tariff rates, facility-percentage allocations for communications, and traffic forecasts. This data base can be used as is, or selective changes can be made by using various model inputs. This section describes in detail each of these inputs. Card formats, definitions, and units are presented for nine different card types which may be used to modify the internal data base. Data inputs are usually specified with a certain number of decimal places. The computer will assume a decimal point at the appropriate place when a string of digits is entered. The user may override this assumption by using a decimal point in the digit string being entered. When a decimal point is entered, it will count as a digit.

2.1 PROGRAM SET-UP (REQUIRED)

Four cards are required to set up each program run. The first three are job control cards, and the fourth is a run description card. Job control cards are required by the computer and are specific to the Transportation Computer Center system. The run description card is printed out, as written, at the top of the output listing. This allows the user to provide a label for each run describing the scenario being analyzed. Up to 72 characters can be used, starting in the first column. A blank card can be substituted when a label is not desired.

Figure 2-1 shows the program set-up sequence with a typical run description card. The first three cards must be identical to the ones shown.

2.2 FACILITIES AND EQUIPMENT (OPTIONAL)

All quantities and costs associated with a given facility type can be modified by using F&E cards. F&E costs are one-time expenses for the purchase and installation of additional facilities. There are 14 specific categories that can be changed as shown below. Most of the categories distinguish between "old" and "new" facilities. A new facility refers to a new technology piece of equipment that replaces an existing or old piece of equipment. The old and new equipment will likely have different costs. Old equipment is phased out and new equipment in according to a transition

schedule as described in Section 2-4. Where a transition schedule has been specified, the old costs apply to the pre-transition equipment and the new costs apply to the new technology equipment. Where there is no transition, only the old costs apply.

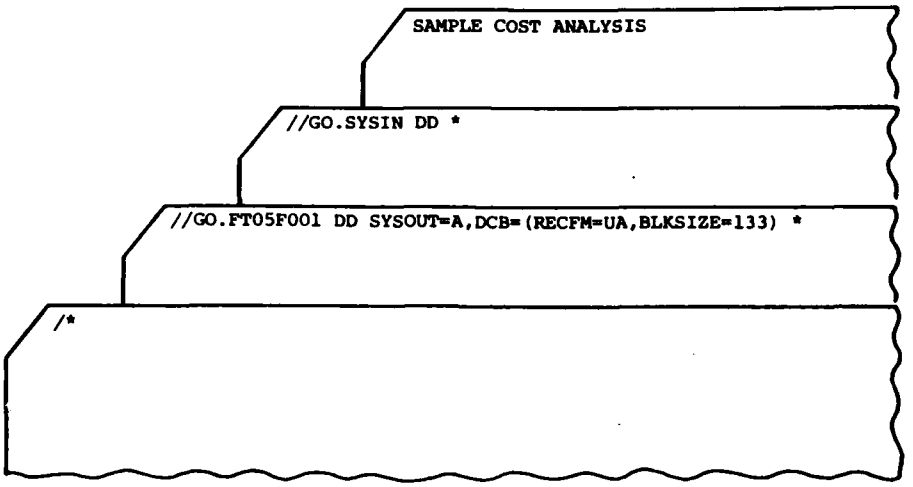


Figure 2-1. PROGRAM SET-UP CARDS

1. Basic Cost of an Old Facility. This is the average cost per facility associated with baseline installations. It is equivalent to the purchase price of the entire facility. (Units: thousands of dollars)

2. Basic Cost of a New Facility. This is the average cost per facility associated with new installations. Unless specified by the user, it is equal to No. 1. (Units: thousands of dollars)

3. Old Facility Cost Increase per Sector. The average increase in the cost of an old facility due to the addition of one sector. (Units: thousands of dollars per additional sector)

4. Old Facility Cost Increase per Center. The average increase in the cost of an old facility due to the addition of one center. (Units: thousands of dollars per additional center)

5. Old Facility Cost Increase per Tower. The average increase in the cost of an old facility due to the addition of one tower. (Units: thousands of dollars per additional tower)

6. Old Facility Cost Increase per Terminal Radar. The average increase in cost of an old facility due to the addition of one terminal radar unit. (Units: thousands of dollars per additional radar)

7. Old Facility Cost Increase per Flight Service Station. The average increase in the cost of an old facility due to the addition of one FSS. (Units: thousands of dollars per additional FSS)

8. New Facility Cost Increase per Sector. The average increase in cost of a new facility due to the addition of one sector. Unless specified by the user, it is equal to No. 3. (units: thousands of dollars per additional sector)

9. New Facility Cost Increase per Center. The average increase in cost of a new facility due to the addition of one center. Unless specified by the user, it is equal to No. 4. (Units: thousands of dollars per additional center)

10. New Facility Cost Increase per Tower. The average increase in cost of a new facility due to the addition of one tower. Unless specified by the user, it is equal to No. 5. (Units: thousands of dollars per additional tower)

11. New Facility Cost Increase per Terminal Radar. The average increase in cost of a new facility due to the addition of one terminal radar unit. Unless specified by the user, it is equal to No. 6. (Units: thousands of dollars per additional radar)

12. New Facility Cost Increase per Flight Service Station. The average increase in cost of a new facility due to the addition of one FSS. Unless specified by the user, it is equal to No. 7. (Units: thousands of dollars per additional FSS).

13. Percent of Cost Due to Communications. The percentage of the basic facility cost that can be attributed to communications. It is the same for both old and new facilities. Note that any cost increases specified in 3 through 12 are assumed to be 100 percent communications. Unless specified by the user, facility types 65 through 95 are assumed to be 100 percent communications. (Units: 000 to 100 percent). The 77 card (see Section 2.7) can be used to set all of the communications percentages to the same value.

14. Number of Facilities Required in the System. These data are normally used to specify the total number of facilities required when a new type of facility is being defined.

Additions and modifications are made for each facility type by using a Type 1 card. The format is illustrated in Figure 2-2. Columns on these cards are assigned as follows:

Col 1 - must be a zero

Col 3-4 - two-digit facility type; 01 through 95 are permitted

Col 6-7 - two-digit number indicating the first category to be changed

Col 9-14 - six-digit number representing the new value

Col 16-17 - two-digit number indicating the second category to be changed

Col 19-24 - six-digit number representing the new value

etc.

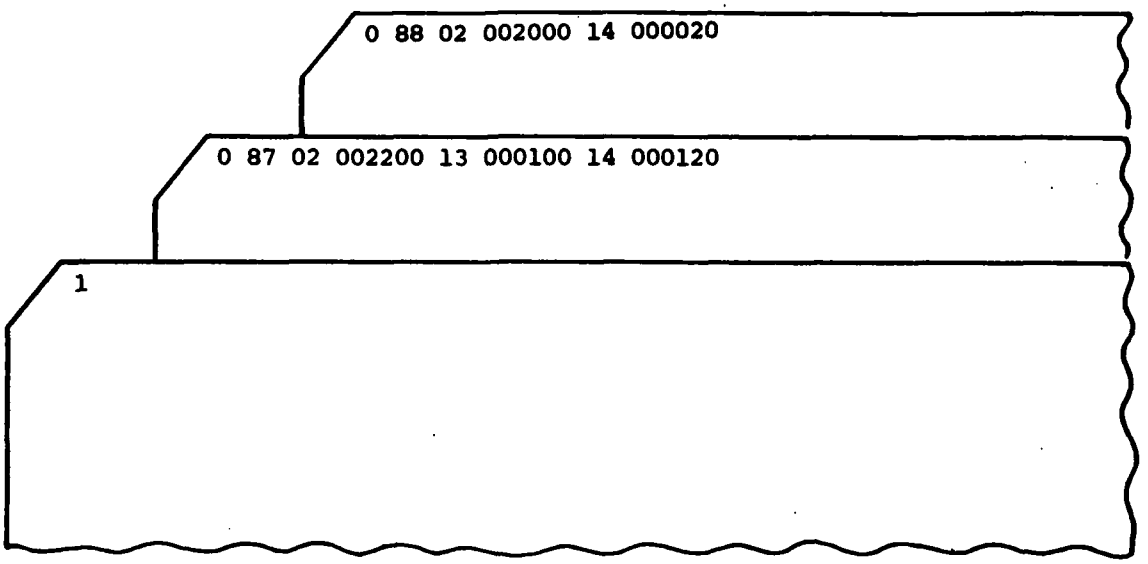


Figure 2-2. F&E COST CARDS

Up to seven changes can be entered on one card. If additional changes are required, a second card is used to continue. Since numbers must be right-justified, it is recommended that all leading zeros be typed to minimize key punch errors. Only one facility type is permitted on a card. All Type 1 cards must be placed together and preceded by a card with the digit "1" typed in the first column.

A complete English-language listing of F&E changes will be printed out at run time. It will indicate the facility type, the nature of the change, the default value before the change, the value after the change, and the year the change is to become effective. (Note that the year is printed only if the Type 4 cards precede Type 1 cards when data are entered). Appendix A contains a complete listing of the F&E parameters assumed in the model. The user should refer to this appendix when modifying any F&E data.

2.3 OPERATIONS AND MAINTENANCE (OPTIONAL)

All Operations and Maintenance (O&M) costs associated with a given facility type can be modified by using O&M cards. The maintenance cost for a given facility is expressed as the sum or a fixed cost (includes materials, supplies, and spare parts) and a labor cost. Labor costs can be allocated up to three labor categories, each having a different wage rate. Thus, the maintenance cost can be expressed as:

$$C_i = A_i + \sum_{j=1}^{3} W_j H_{ji}$$

---

*See Appendix D for a list of the facility types used in the model.

where

C_i = maintenance cost of the ith facility, in thousands of dollars per year

A_i = fixed cost of the ith facility, in thousands of dollars per year

W_j = wage rate, labor class j, in thousands of dollars per year

H_{ji} = man-years of labor class j required to maintain the ith facility for a given year

In the modeling of the labor cost for a facility, one, two, or all three of the H variables may be set to zero. In the latter case, the maintenance cost is modeled as a constant, as in previous versions of the model.

There are 19 different categories of O&M costs that can be modified by the user, as shown below. Most of them distinguish between old and new technology facilities, as was also the case in the F&E cards.

1. Maintenance Fixed Cost of an Old Facility. (Units: thousands of dollars per year)

2. Maintenance Fixed Cost of a New Facility. The average O&M cost per facility associated with new installations. Unless specified by the user, it is equal to No. 1. (Units: thousands of dollars per year)

3. Old Maintenance Cost Increase per Sector. The average increase in O&M cost for an old facility due to the addition of one sector. (Units: thousands of dollars per year per additional sector)

4. Old Maintenance Cost Increase per Center. The average increase in O&M cost for an old facility due to the addition of one center. (Units: thousands of dollars per year per additional center)

5. Old Maintenance Cost Increase per Tower. The average increase in O&M cost for an old facility due to the addition of one tower. (Units: thousands of dollars per year per additional tower)

6. Old Maintenance Cost Increase per Terminal Radar. The average increase in O&M cost for an old facility due to the addition of one terminal radar unit. (Units: thousands of dollars per year per additional radar)

7. Old Maintenance Cost Increase per Flight Service Station. The average increase in O&M cost for an old facility due to the addition of one FSS. (Units: thousands of dollars per year per additional FSS)

8. New Maintenance Cost Increase per Sector. The average increase in O&M costs for a new facility due to the addition of one sector. Unless specified by the user, it is equal to No. 3. (Units: thousands of dollars per year additional sector)

9. New Maintenance Cost Increase per Center. The average increase in O&M costs for a new facility due to the addition of one center. Unless specified by the user, it is equal to No. 4. (Units: thousands of dollars per year per additional center)

10. New Maintenance Cost Increase per Tower. The average increase in O&M costs for a new facility due to the addition of one tower. Unless specified by the user, it is equal to No. 5. (Units: thousands of dollars per year per additional tower)

11. New Maintenance Cost Increase per Radar. The average increase in O&M costs for a new facility due to the addition of one terminal radar unit. Unless specified by the user, it is equal to No. 6. Units: thousands of dollars per year per additional radar)

12. New Maintenance Cost Increase per Flight Service Station. The average increase in O&M costs for a new facility due to the addition of one FSS. Unless specified by the user, it is equal to No. 7. (Units: thousands of dollars per year per additional FSS)

13. Percent of Cost Due to Communications. The percentage of the basic O&M cost that can be attributed to communications. It is the same for both old and new facilities. This percentage need not be the same as the communications percentage for facilities and equipment cost. Note that all cost increases appearing in Numbers 3 through 12 are assumed to be 100 percent communications and, unless specified by the user, facility types 65 through 95 are assumed to be 100 percent communications. (Units: 0 to 100 percent). The 77 card (see Section 2.7) can be used to set all the O&M communications percentages to the same value.

14. Annual maintenance labor years for an old facility, labor category 1. (Units: labor years per facility per year)

15. Annual maintenance labor years for an old facility, labor category 2. (Units: labor years per facility per year)

16. Annual maintenance labor years for an old facility, labor category 3. (Units: labor years per facility per year)

17. Annual maintenance labor years for a new facility, labor category 1. If not specified, this will be set equal to No. 14. (Units: labor years per facility per year).

18. Annual maintenance labor years for a new facility, labor category 2. If not specified, this will be set equal to No. 15. (Units: labor years per facility per year)

19. Annual maintenance labor years for a new facility, labor category 3. If not specified this will be set equal to No. 16. (Units: labor years per facility per year)

Additions and modifications are made for each facility type by using a Type 2 card. The format is illustrated in Figure 2-3. Columns on these cards are assigned as follows:

Col 1 - must be a zero

Col 3-4 - two-digit facility type; 01 through 95 are permitted

Col 6-7 - two-digit number indicating the first category to be changed

Col 9-14 - six-digit number representing the new value

Col 16-17 - two-digit number indicating the second category to be changed

Col 19-24 - six-digit number representing the new value

etc.

Up to seven changes can be entered on one card. If additional changes are required, a second card is used to continue; Columns 1 through 5 must be identical to the previous card in this case.

A Type 2 card may also be used to change the maintenance labor class rates. These rates represent unloaded salaries and are expressed in

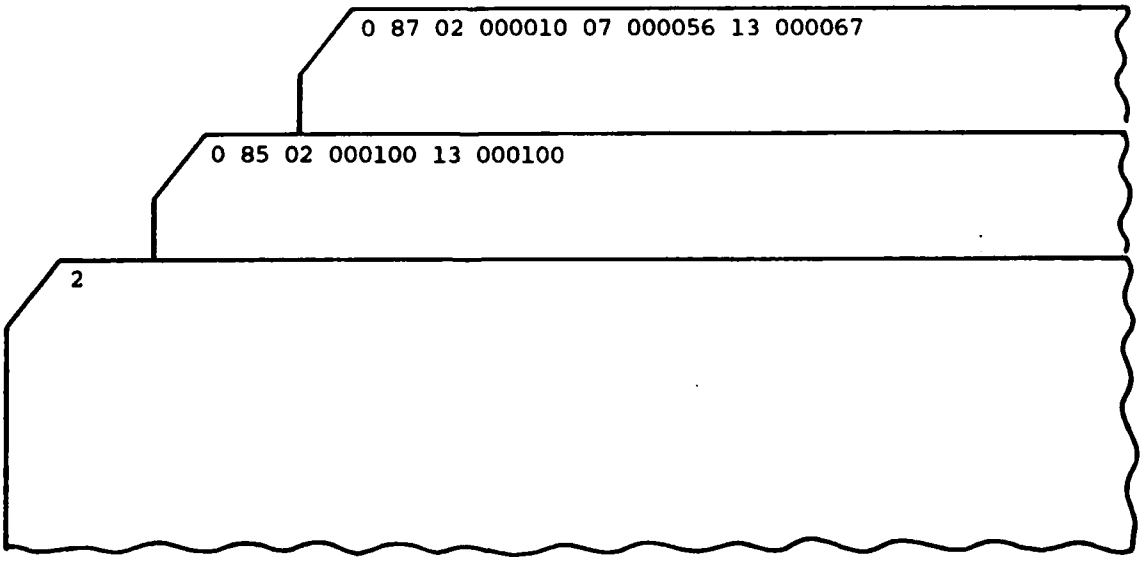


Figure 2-3. O&M COST CARDS

thousands of dollars per year. Columns for this particular change are assigned as follows:

Col 1 - must be zero

Col 7 - single digit indicating the first labor category to be changed (must be 1, 2, or 3)

Col 9-14 - new wage rate for the given category, in thousands of dollars per year

Col 17 - single digit indicating the second labor category to be changed, if applicable

Col 19-24 - new wage rate, if applicable

etc.

Only one facility type is permitted on a card. All Type 2 cards must be placed together and preceded by a card with the digit "2" typed in the first column. A complete English-language listing of all O&M changes will be printed out at run time. It will indicate the facility type, the nature of change, the default value before the change, the value after the change, and the year in which the change becomes effective. All costs are printed out in thousands of dollars per year.

Whenever O&M cards are used to define a new facility type, it is important to include a Type 1 F&E card indicating the number of facilities required. Otherwise, the computer uses a default value of zero for the number of facility types in categories 65 through 95.

Appendix B contains a complete listing of all O&M costs assumed in the model. Whenever modifications are made the user should refer to this appendix.

2.4 TRANSITION FACTORS (OPTIONAL)

In any scenario where equipment is being phased in or out, the user must specify an implementation schedule for F&E and O&M expenditures. For new-technology equipment entering service, the user must specify the quantities being procured each year and how much of that quantity, if any, is to be installed and made available for service. For old-technology equipment going out of service, the user must specify how much of it needs to remain in service to get the job done while the new equipment is being phased in.

These factors are expressed as percentages of the total requirement for a particular facility type in a given year, where the requirement is defined as that quantity of equipment, whether old or new technology, needed to meet the demands placed on it by other parts of the ATC system. When 100 percent of the requirement is satisfied by old equipment and 0 percent by new equipment, the transition has not yet begun; when these figures are reversed, the transition period is over. During transition, the old percentage should be steadily decreasing and the new percentage increasing.

There are four transition parameters that may be modified by the user, two for F&E expenditures and two for O&M expenditures. These are as follows:

- F&E Transition Factors
  - (1) Quantity of old equipment in place, expressed as a percentage of the total facility requirement. These data are not used by the program, but a field is provided to simplify card formatting requirements.
  - (2) Quantity of new equipment in place, expressed as a percentage of the total facility requirement. This represents the amount of new-technology equipment that must have been procured in a given year. Note that procuring a facility does not mean that the facility is operational, only that F&E funds for the appropriate number of units are allocated for the years specified.
- O&M Transition Factors
  - (1) Quantity of old equipment that is in service and being maintained, expressed as a percentage of the total facility requirement. O&M costs for old facility types will be applied to this equipment.
  - (2) Quantity of new equipment that is in service and being maintained, expressed as a percentage of the total facility requirement. New O&M costs will be applied to this equipment.

Transition factors may be included in a run by using Type 4 cards. The format is illustrated in Figure 2-4. The columns on these cards are assigned as follows:

Col 1 - must be a zero

Col 3-4 - two-digit facility type; 01 through 95 are permitted

Col 6-7 - two alpha-characters indicating whether the transition is for F&E or O&M costs. (Enter an F&E or O&M in this space)

Col 9 - single digit; a one (1) indicates that the percentage applies to old equipment; a two (2) indicates the percentage applies to new equipment

Col 11-13 - equipment life in years; this figure must be right-justified

Col 16 - Single-digit transition mode; a one (1) indicates that old equipment will be zero after the transition; two (2) indicates that the last values for both old and new are to be maintained for all subsequent years; and three (3) indicates that new equipment is to be phased out and replaced with old. These modes are explained in more detail below.

Col 18-21 - the year in which transition begins; four digits

Col 23-25 - three digits; the percentage applicable in the first year

Col 27-29 - three digits; the percentage applicable in the second year

etc.

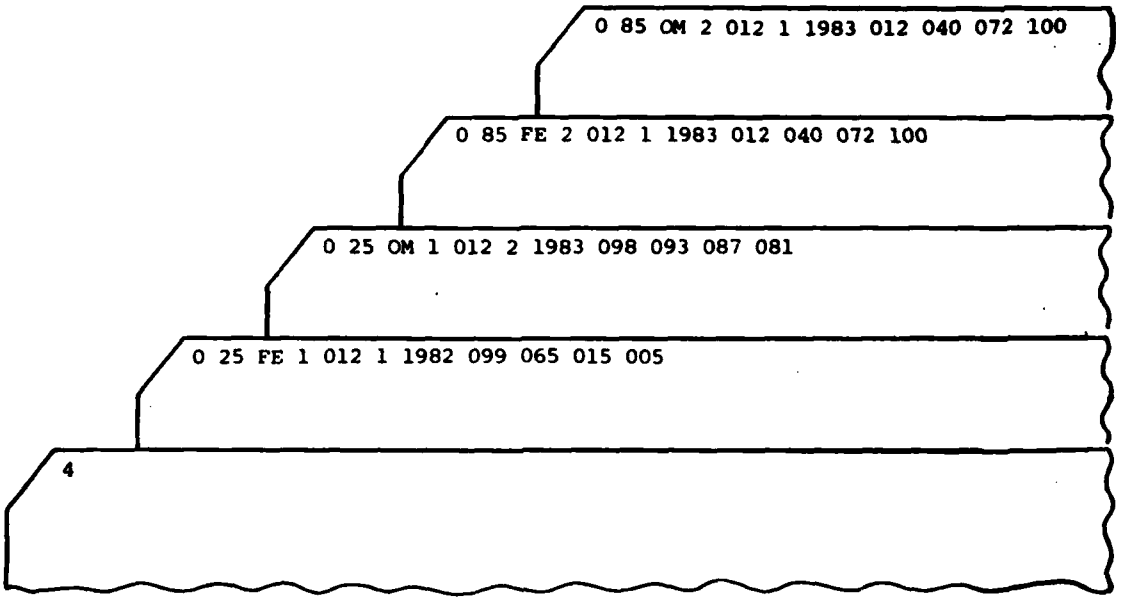


Figure 2-4. TRANSITION CARDS

Up to 10 percentage values can be entered on a single card; if an implementation schedule requires more than 10 years, an asterisk (*) is placed in column 80 of the card and the process is continued on a second card, beginning with columns 2-4.

The model makes no validity checks of any transition data input by the user; however, there are two conditions that must hold for the factors to be consistent. First, the percentage of new equipment to be maintained (O&M No. 2, above) must be less than or equal to the percentage of new equipment in place (F&E No. 2, above). This is simply saying that facilities cannot be maintained until they are built. Second, the sum of the percentages for old equipment to be maintained (O&M No. 1) and for new equipment to be maintained (O&M No. 2) must be greater than or equal to 100 percent. This means that enough equipment must be maintained to satisfy at least 100 percent of the demands on it.

The difference between the three transition modes is subtle and merits further discussion. The transition data are specified as a percentage of the current requirement. Thus, even if a constant percentage is specified over a time interval, the number of facilities involved is likely to increase because the requirements will be changing.

In Mode 1, the last percentage specified for F&E and for new O&M will prevail for the remaining years in the analysis. However, the transition parameter for old O&M is assumed to be zero after the transition is over. This mode is normally used when a particular facility type is to be phased out or replaced by a new type. Under Mode 2, the last value of all three parameters would prevail after the end of the transition period. This mode would be used if it was desirable to maintain a residual group of old facilities (for backup, perhaps) after the transition was completed. Specified equipment life is not a factor in the calculations of Modes 1 and 2. F&E costs are incurred only for growth; maintenance and replacement costs are assumed to be covered by O&M costs.

Mode 3 can be used to do a life-cycle analysis of a new-technology facility. At the end of the transition period, new equipment is phased out according to its specified life and replaced with the old-technology equipment. While this situation is not likely to occur in the "real world," it is useful for assessing the cost impact of adding a few pieces of new equipment and following them through a life cycle. During the transition period under Mode 3, the number of facilities is calculated in the same way as in the other two modes. New equipment added "n" years ago, where "n" is the equipment life, will be removed from service. This will permit a calculation of the number of additional new facilities required in the current year. After transition, no additional new facilities are added, and the existing new facilities will grow old and be lost because of attrition. After transition, all new facilities are maintained. The number of old facilities is chosen so that the number of new facilities plus the number of old facilities equals the facility requirement. If the required number of old facilities exceeds the number of old facilities before transition, then F&E costs will be incurred for the excess. The old facilities that go out of service during the transition period are assumed to be "on the shelf" and therefore readily placed back in service when required later.

A sample transition specification is shown in Table 2-1. The table shows the result of each of the three modes for the sample transition and illustrates many of the rules described above.

2.5 TARIFF SCHEDULES (OPTIONAL)

Up to nine tariff schedules may be used in a run. A tariff schedule consists of the average monthly cost per mile for a particular circuit type and the average monthly termination charge for both ends. Frequently, published tariffs have mileage rates that are dependent on the length of the circuit. In these cases, the user can estimate average circuit lengths with the aid of the switching matrices described in Section 2.8. Average cost per mile can then be computed by the user from the published tariff.

Two tariff schedules are contained in the program, one for TELPAK and one for private lines. Changes to these two tariffs and additional tariffs

Table 2-1. SAMPLE TRANSITION SCHEDULE (EQUIPMENT LIFE = THREE YEARS)

Facility Requirement	Transition Percentages			Number of Facilities											
				Mode 1				Mode 2				Mode 3			
	New F&E	Old O&M	New O&M	#Old	#New	#New Added	#New Operational	#Old	#New	#New Added	#New Operational	#Old	#New	#New Added	#New Operational
100	0	100	0	100	0	0	0	100	0	0	0	100	0	0	0
110	40	100	20	110	44	44	22	110	44	44	22	110	44	44	22
120	70	60	50	72	84	40	60	72	84	40	60	72	84	40	60
130	90	30	80	39	117	33	104	39	117	33	104	39	117	33	104
140	100	10	100	14	140	23	140	14	140	23	140	14	140	67	140
150	-	-	-	0	150	10	150	15	150	10	150	50	100	0	100
160	-	-	-	0	160	10	160	16	160	10	160	93	67	0	67
170	-	-	-	0	170	10	170	17	170	10	170	170	0	0	0
180	-	-	-	0	180	10	180	18	180	10	180	180	0	0	0
190	-	-	-	0	190	10	190	19	190	10	190	190	0	0	0
200	-	-	-	0	200	10	200	20	200	10	200	200	0	0	0

can be accommodated by using Type 5 cards. The format for these cards is illustrated in Figure 2-5. The columns are assigned as follows:

Col 1 - must be a zero

Col 3 - one-digit number representing a tariff schedule; must be 1-9

Col 5-10 - six-digit number equal to the average lease cost, in dollars per mile per month. A decimal point is required.

Col 12-17 - six-digit number equal to the average cost, in dollars per month, to terminate both circuit ends. A decimal point is required.

Each Type 5 card must contain both the cost per mile and the service-termination charges even if one does not change.

2.6 USER-ASSIGNED COSTS (OPTIONAL)

The user may input special costs that are not manipulated by the model but are important in the overall cost analysis. For new systems, these costs might include:

- Research and development
- Training
- Documentation
- One-time installation requirements
- Avionics costs for equipment required aboard aircraft

These different costs are added for each year and input on Type 6 data cards by the user. Figure 2-6 illustrates a typical user entry. The columns are assigned as follows:

Col 1 - must be a zero

Col 3-6 - four-digit number representing the first year having user-assigned costs (thousands of dollars)

Col 8-14 - seven digits representing the total user-assigned costs for the first year (thousands of dollars)

Col 16-22 - seven digits representing the total user-assigned costs for the second year (thousands of dollars)

etc.

Costs for up to eight years can be entered on one card. Additional Type 6 cards can be used to enter data for other years between 1979 and 1999. User-assigned costs are zero for all years not specified. For this command, costs should be entered in 1979 dollars.

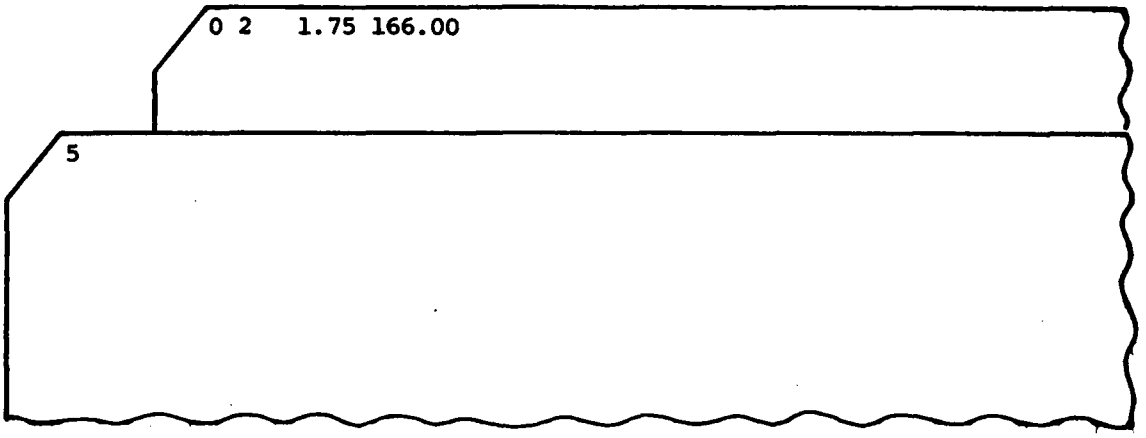


Figure 2-5. **TARIFF CARDS**

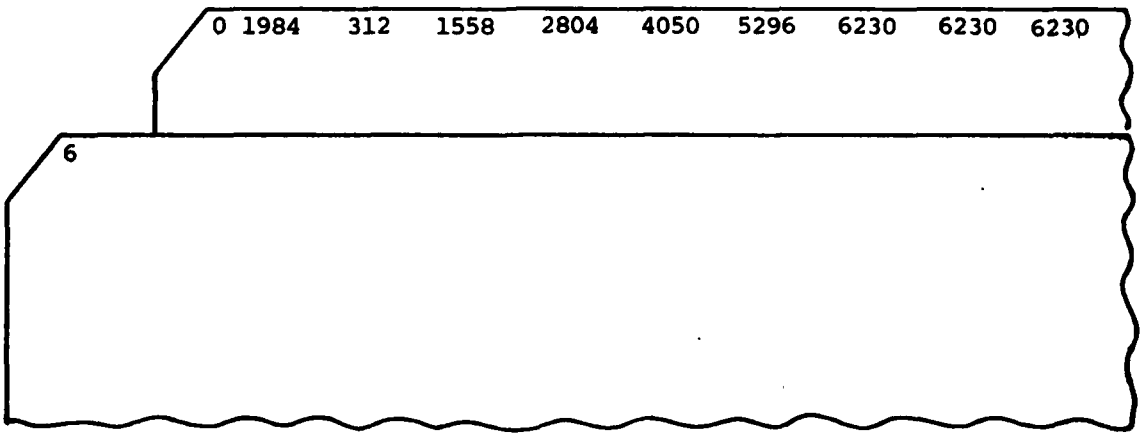


Figure 2-6. **USER COST CARDS**

2.7 INTEREST AND AUTOMATION FACTORS (REQUIRED)

The model contains provisions for three types of inflation as well as a discounting factor for the value of money. Various adjustments to the model representing changes in the level of facility automation and changes in traffic estimates are also possible. All of these changes are entered on Type 7 cards and must be included for every run. Figure 2-7 illustrates a set of Type 7 cards. The first card always contains a "7" in the first column. The next two cards are referred to as the "71" and "72" cards, respectively. Columns on the 71 card are assigned as follows:

Col 1-2 - 71

Col 4-6 - Inflation rate applied to all F&E costs (000 to 100 percent)

Col 8-10 - Inflation rate applied to all O&M costs (000 to 100 percent)

Col 12-14 - Inflation rate applied to all leased costs, including circuits (000 to 100 percent)

Col 16-18 - Discounting factor representing the future value of money. This interest rate is used to convert all future cash flows to a common basis. To comply with OMB guideline A-94 the proper discount factor to use in the model should equal the appropriate discount rate plus inflation. It is also used to estimate the future value of user-assigned costs (000 to 100 percent)

Col 20-23 - Number of radar sectors in 1979 if different from the default value of 740. (Four digits; a decimal point is assumed after the second digit.)

Col 25-28 - Sector Productivity Factor. The number of sectors computed is divided by this factor to reflect cost reductions due to productivity. The default value is 1.0. (Four digits; a decimal point is assumed after the second digit.)

Col 30-33 - Center Productivity Factor. The number of centers is divided by this factor to reflect cost reductions due to productivity. The default value is 1.0. (Four digits; a decimal point is assumed after the second digit.)

Col 35-38 - Tower Productivity Factor. The number of towers computed is divided by this factor. The default value is 1.0. (Four digits; a decimal point is assumed after the second digit.)

Col 40-43 - Terminal Radar Productivity Factor. The number of terminal radars is computed and divided by this factor. The default value is 1.0. (Four digits; a decimal point is assumed after the second digit.)

Col 45-48 - Flight Service Stations (FSS) Productivity Factor. The number of FSSs is divided by this factor to reflect cost reductions due to productivity. The default value is 1.0. (Four digits; a decimal point is assumed after the second digit.)

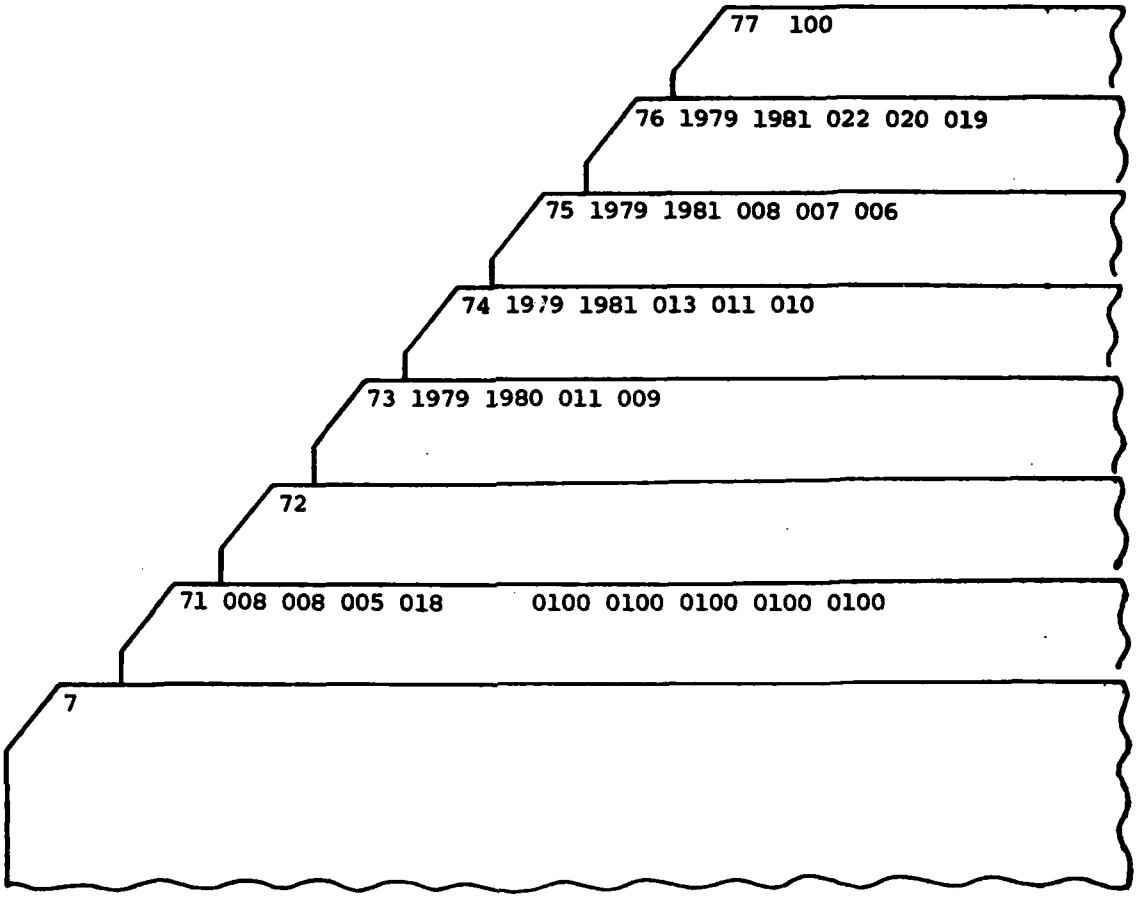


Figure 2-7. INFLATION AND TRAFFIC GROWTH CARDS

The inflation factors specified on the 71 card are used in the computation of all F&E, O&M, and leased costs. The model first calculates these costs in constant 1979 dollars. The calculated costs are then inflated according to the specified inflation rates to arrive at cost figures in current dollar terms. The inflation rate to be applied is defined as the percentage change in cost of the same quantity of the same product, from one year to the next. As such, it already reflects any gains in productivity that may have occurred; it refers only to the over-the-counter price. The average of the F&E and O&M inflation rates is assumed to be the inflation associated with all user-assigned costs.

The discount rate reflects the relative value of money over time. Applying this factor allows costs or benefits to be added over time. According to OMB Circular A-94, the proper discount rate to use is 10 percent. This figure represents an estimate of the average rate of return on private investment, before taxes and after inflation. In the communications model, the discount factor is applied to the inflated dollar figure. Thus, to comply with A-94 in using the model, it is necessary to add the inflation rate to the 10 percent discount rate to obtain the inflation adjusted discount rate

for each given year. Since there are three different inflation rates used by the model, the user will need to develop a composite inflation rate. One approach might be to take the mean of the F&E rate, which is essentially an inflation rate on capital expenditures, and the O&M rate, which is essentially an inflation rate on labor.

The values specified on the 71 card will apply to all years of the simulation. If it is desired to change inflation rates for specific years, a 73, 74, 75, or 76 card, described below, must be given subsequent to the required 71 card.

The 71 card also allows the user to modify the number of sectors assumed in the baseline year. Subsequent quantities are then computed on the basis of nominal sector growth. A productivity factor, however, can be used to modify the rate of sector growth. The computed value is divided each year by the productivity factor appearing on the 71 card. This is normally used to account for the effects of facility automation and increased productivity as a result of technology. Productivity factors for centers, towers, terminal radars, and FSS may be used as well. Unless specified, a default value of 1.00 is assumed for all productivity factors.

The 72 card is used to input factors affecting traffic growth. When desired, the new traffic volume (in millions per year) is entered for Instrument Flight Rules (IFR) traffic, airport operations, instrument operations at airports, or flight operations. These values will be used for each year of the analysis. This provides a method of holding traffic levels constant during a run. The 72 card is also used to change the rate of traffic growth assumed in the model. The percentages entered on this card cause the amount of traffic increase, with respect to the baseline, to be multiplied by this factor. Columns on the 72 card are assigned as follows:

Col 1-2 - 72

Col 4-9 - IFR traffic volume in millions per year. (Six digits; the last digit is assumed to be in tenths of a million.)

Col 11-16 - Total Airport Operations in millions per year. (Six digits; the last digit is assumed to be in tenths of a million.)

Col 18-23 - Instrument operations at airports in millions per year. (Six digits; the last digit is assumed to be in tenths of a million.)

Col 25-30 - Flight services in millions per year. (Six digits; the last digit is assumed to be in tenths of a million.)

Col 32-34 - IFR growth rate in percent (000 to 100)

Col 36-38 - Airport operations growth rate in percent (000 to 100)

Col 40-42 - Instrument operations growth rate in percent (000 to 100)

Col 44-46 - Flight services growth rate in percent (000 to 100)

When data are not specified by the user on a 72 card, nominal values are used by the model; i.e., FAA traffic forecasts with unity growth rates are assumed.

The 73, 74, 75, and 76 cards are used to change the inflation factors in individual years for F&E, O&M, circuits, and the discount rate. A 71 card must have been previously entered to set the initial or nominal values for the inflation rates during the simulation period. The format for these cards is identical. Columns are assigned as follows:

Col 1-2 - command number (73,74,75, or 76)

73 = F&E inflation rate

74 = O&M inflation rate

75 = inflation rate for leased circuits and leased equipment

76 = inflation adjusted discount rate

Col 4-7 - first year for which changes are to be specified

Col 9-12 - Last year for which changes are to be specified

Col 14-16 - first value (000 to 100 percent)

Col 18-20 - second value

etc.

The number of values specified must be equal to (Last year minus first year + 1). Up to 16 values may be specified on a card. If more space is desired, place an asterisk (*) in column 80 and continue with a second card, beginning with the 17th value in columns 2-4.

The 77 card is used to change all the communications percentages (both F&E and O&M) to a single value. These percentages are stored on a facility basis and may vary among facilities. This card allows all these percentages to be changed simultaneously rather than individually as is done with the type 1 and type 2 cards. This command would be useful if, for example, the user wished to set all the percentages at 100 percent to obtain a total cost rather than a communications-oriented cost. The format for this command is as follows:

Col 1-2 - 77

Col 5-7 - percentage (000 to 100)

2.8 CIRCUITS (OPTIONAL)

Circuit data used in the model have been extracted from a data base of about 20,000 leased circuits maintained by the Transportation Systems Center in Cambridge, Massachusetts. The circuits have been grouped four different ways according to various characteristics described below. Within each group, each circuit was allocated to exactly one category. While each group accounts for all the circuits, the different stratifications make it possible to analyze technology changes that affect different cross sections of the ATC system. The user would select whichever stratification provided

the best description of the types of circuits affected in a particular analysis. For example, if an analysis of a data-oriented system such as NADIN were being performed, circuit group 2 (Detailed Voice, Data) would be the logical choice since it contains a more detailed breakdown of data circuits than any of the other groups. A complete description of the circuit categories in each of the four groupings is shown in Table 2-2.

Within a particular run the user must choose one of the four groupings as the data base to be used. Once the choice has been made, the other three categorizations, for all practical purposes, do not exist.

Modifications of these parameters are made by using type 8 cards. The first card must have the digit "8" in the first column. The second card indicates which of the circuit groups is to be used. The format is as follows:

Col 1 - must be a zero

Col 10 - circuit group number (1,2,3, or 4)

Subsequent data cards can modify circuit characteristics within the specified group. Within each group, each category is numbered as in Table 2-2. For each of the circuit categories shown in the table, there are 10 associated parameters:

(1) Switched or Nonswitched. If the circuit is to be switched, this will be a one. Otherwise it is a zero. The default value is assumed to be zero.

(2) Tariff. Indicates which of nine possible tariffs is to be used for pricing a particular circuit type.

(3) Average Length. The average length of all circuits belonging to a particular category. (Units = average miles per circuit)

(4) Average Quantity. The average number of circuits of this type required between given facilities. In general, it is stated with respect to the first facility. Tower-to-center circuit averages, for example, are based on the average number of circuits <u>per Tower</u> between these two facility types.

(5) Total Length. Computed by the model from (3) and (4); cannot be changed by the user. (Units = miles)

(6) Total Quantity. Computed by the model from (4); cannot be changed by the user.

(7) Utilization per circuit. The average number of seconds a circuit is in use during the daily peak hour divided by 3,600. Nominal values are assumed unless the user specifies otherwise.

(8) Total Utilization. Computed by the model from (6) and (7); cannot be changed by the user.

Table 2-2. CIRCUIT CATEGORIZATIONS

CIRCUIT GROUP 1 Circuits According to Type	CIRCUIT GROUP 2 Circuits According to Type (Emphasis on Voice, Data)
1) Miscellaneous voice circuits	1) FSS-to-tower voice circuits
2) FSS-to-tower voice circuits	2) FSS-to-center voice circuits
3) FSS-to-center voice circuits	3) Tower-to-center voice circuits
4) Tower-to-center voice circuits	4) Center-to-center voice circuits
5) Center-to-center voice circuits	5) FSS-to-public voice circuits
6) FSS-to-public voice circuits	6) FSS-to-FSS voice circuits
7) Miscellaneous data circuits	7) Tower-to-tower voice circuits
8) FSS-to-tower data circuits	8) Miscellaneous voice circuits
9) FSS-to-center data circuits	9) FSS-to-center low-speed data circuits
10) Tower-to-center data circuits	10) Miscellaneous low-speed data circuits
11) Center-to-center data circuits	11) Tower-to-center FDEP circuits
12) Miscellaneous radio circuits	12) Tower-to-center ARTS circuits
13) RCAG radio circuits	13) Center-to-center high-speed data circuits
14) FSS radio circuits	14) Miscellaneous high-speed data circuits
15) Tower radio circuits	15) WMSC circuits
16) BUEC radio circuits	16) RCAG radio circuits
	17) FSS radio circuits
	18) Tower radio circuits
	19) BUEC radio circuits
	20) Miscellaneous radio circuits
	21) Other circuits

Table 2-2. (continued)

CIRCUIT GROUP 3 Circuits According to Terminating Facilities	CIRCUIT GROUP 4 Circuits According to Function or Use
1) Tower-to-tower circuits	1) Military-to-FSS circuits
2) Tower-to-FSS circuits	2) Military-to-tower circuits
3) Tower-to-center circuits	3) Military-to-center circuits
4) Tower-to-military circuits	4) Autovon circuits
5) Tower-to-VOR circuits	5) Miscellaneous military circuits
6) Tower-to-foreign exchange	6) ILS circuits
7) Tower-to-RCO circuits	7) VORTAC circuits
8) Tower-to-ILS circuits	8) DF circuits
9) Tower-to-weather circuits	9) Tower-to-center circuits
10) Miscellaneous tower circuits	10) FSS-to-center circuits
11) Center-to-center circuits	11) FSS-to-tower circuits
12) Center-to-FSS circuits	12) Center-to-RCAG circuits
13) Center-to-military circuits	13) Tower-to-RTR circuits
14) Center-to-RCAG circuits	14) Center-to-BUEC circuits
15) Center-to-BUEC circuits	15) FSS-to-RCO circuits
16) Center-to-ARSR circuits	16) Foreign exchange
17) Center-to-RTR circuits	17) Miscellaneous communications circuits
18) Center foreign exchange	18) Special circuits
19) Center miscellaneous circuits	19) Weather circuits
20) FSS-to-FSS circuits	20) ARSR circuits
21) FSS-to-military circuits	21) Other circuits
22) FSS-to-VOR circuits	
23) FSS-to-foreign exchange circuits	
24) FSS-to-RCO circuits	
25) FSS-to-RTR circuits	
26) FSS-to-weather circuits	
27) Miscellaneous FSS circuits	
28) Special circuits	
29) Other circuits	

(9) Equipment Cost per Circuit. The average monthly cost of any special equipment associated with this circuit type. (Units = dollars per month)

(10) Required Grade of Service. Expressed as the maximum allowable probability of all circuits being busy. A practical range for this variable is about 0.1 for the lowest-priority data circuits to 0.001 or 0.0001 for the controller-to-controller voice circuits.

The format for changes to the circuit data base is illustrated in Figure 2-8. Up to five changes can be entered on one card. Additional changes require the use of a second card. Only one circuit category is permitted on a card, and all type 8 cards must be placed together. The columns on each data card are assigned as follows:

Col 1 - must be a zero

Col 3-4 - two-digit circuit type (00 to 16)

Col 6-7 - two-digit number indicating the first parameter to be changed

Col 9-16 - six-digit number representing the value of the first parameter

Col 18-19 - two-digit number indicating the second parameter to be changed

Col 21-28 - six-digit number representing the value of the second parameter

etc.

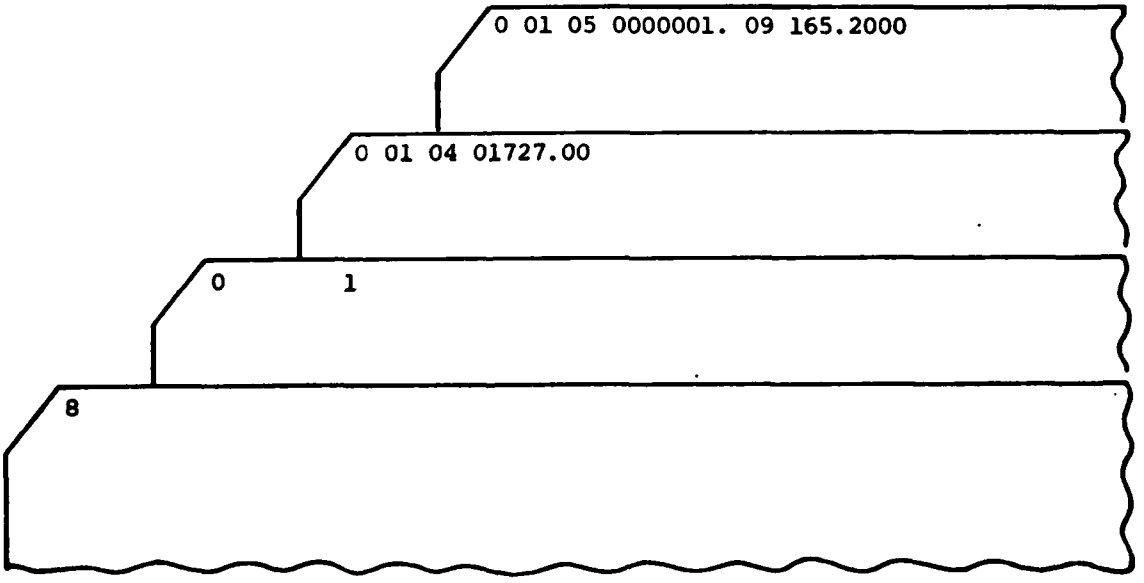


Figure 2-8. CIRCUIT PARAMETER CARDS

Provision is made for all data to be entered to the nearest whole number. The user may override this feature by including a decimal point at any desired place as long as the total number of digits, including the decimal, does not exceed six.

2.9 REPORTS (REQUIRED)

A Type 9 card is mandatory for all runs. It tells the processor which reports are to be generated and the period of interest between 1979 and 1999. Years outside of this range are not accepted.

A typical Type 9 card is illustrated in Figure 2-9. The columns are assigned as follows:

Col 1 - must be a zero

Col 3-6 - first year of the analysis period (four digits)

Col 8-11 - last year of the analysis period (four digits)

Col 13 - first report desired

Col 15 - second report desired

Col 17 - third report desired

etc.

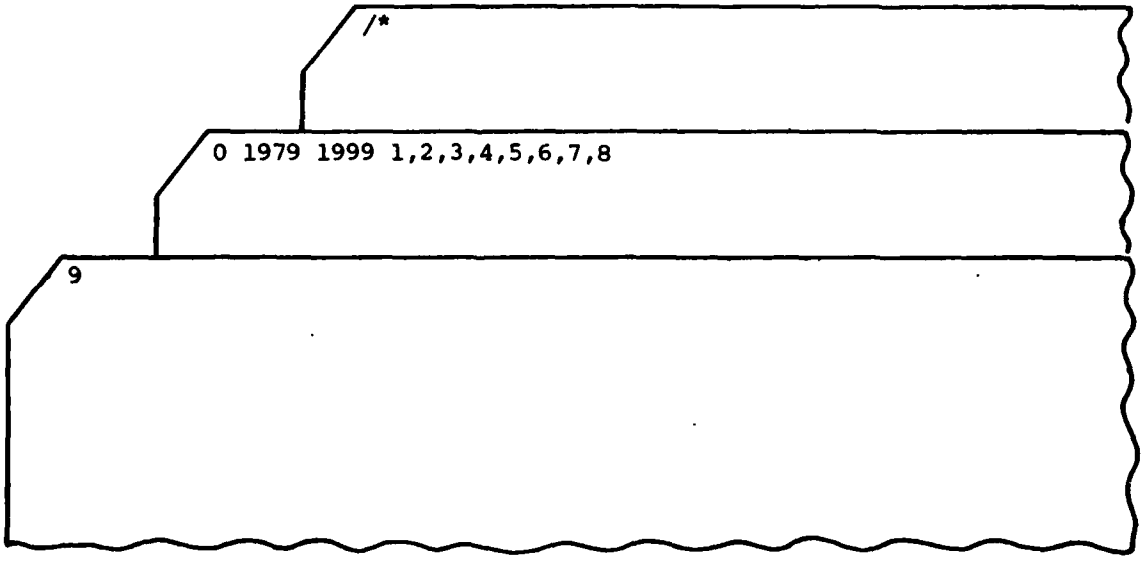


Figure 2-9. ANALYSIS PERIOD AND REPORT CARDS

Eight types of reports are available:

(1) Detailed cost summary

(2) Short summary

(3) F&E data for 1979

(4) O&M data for 1979

(5) Tariff report

(6) Operational units required (listed for each year)

(7) Circuit parameters (listed for each year)

(8) Main array (listed for each year)

Entering report numbers in columns 13 through 27 causes the reports to generate. If no report type is specified, only the detailed cost summary will be printed. Appendix C contains descriptions and examples of each report type. The user should refer to this appendix when it is necessary to interpret data in a report.

The Type 9 cards must be followed by a card that signals the processor to begin execution. This card is pictured in Figure 2-9; it contains "/*" in the first two columns.

SECTION THREE

SAMPLE RUN

This section describes a sample run using many of the model features. It is based on a scenario that involves replacing certain vacuum-tube radios with solid-state equipment and simultaneously implementing a system for remote maintenance monitoring. Each of the required data cards for this analysis is shown, together with an explanation of the input parameters. The output reports are not included in this chapter but are presented in Appendix C with explanations of the various columns.

3.1 PROGRAM SET-UP

Figure 3-1 shows the four cards necessary to initiate the program. The fourth card actually serves to label the output listing for user identifications.

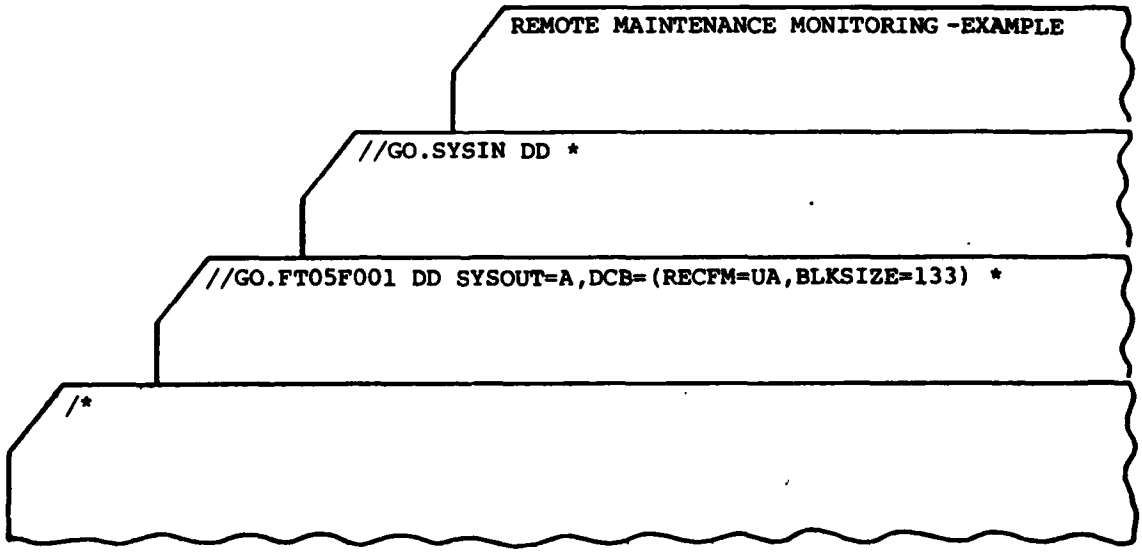


Figure 3-1. PROGRAM SET-UP

3.2 F&E COST DATA

Three new facilities will be used to describe the modernization and maintenance packages. The data cards for these facilities are shown in Figure 3-2. Since allocation of new facility types starts at 65, new equipment will be assigned to types 65, 66, and 67 in the model. Type 65 will represent the new solid-state radio. The estimated cost of equipment and installation per site is $28,000. These costs fall under category 02 (see Section 2.2). The total number of facilities required consists of 556 RCAG sites plus 722 RTRs; category 14 is accordingly assigned 1,287 units.

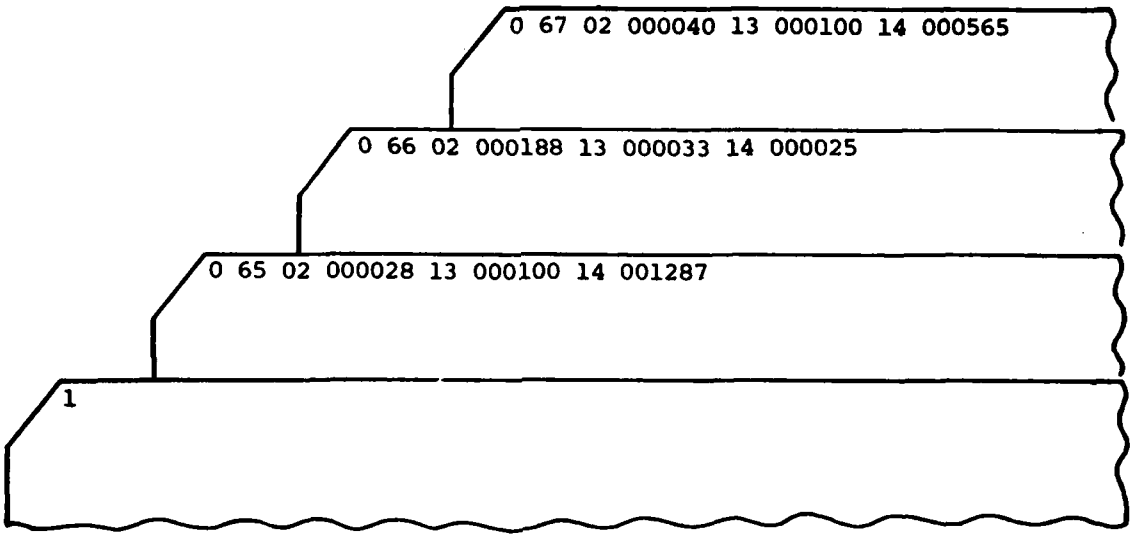


Figure 3-2. F&E COST DATA

The second facility required is a central computer to monitor the remote sites. This will be assigned to facility type 66. The estimated cost of each computer is $150,000 with a 25 percent margin for error included, bringing the total cost per facility to $188,000. Altogether, 25 computer facilities will be required.

The last facility type is number 67. This consists of the actual monitoring equipment that must be installed at each RCAG. The estimated cost is $40,000 per site, including a 25 percent margin for error. One-hundred percent of the cost is attributed to communications, and 565 sites will be affected.

3.3 O&M COST DATA

The new solid-state equipment with remote monitoring is expected to produce an overall reduction in O&M costs. This net saving is reflected in category 02 (see Section 2.3) of the O&M data cards for RCAGs and RTRs. The new O&M cost of facility type 48 (RCAG) will be $8,000 per year. The O&M cost for RTRs (facility type 52) will be $15,000 per year. Since the percentage allocated to communications has not been specified, the model will continue to use the nominal percentages applied to the original facilities. The appropriate O&M changes are illustrated in Figure 3-3.

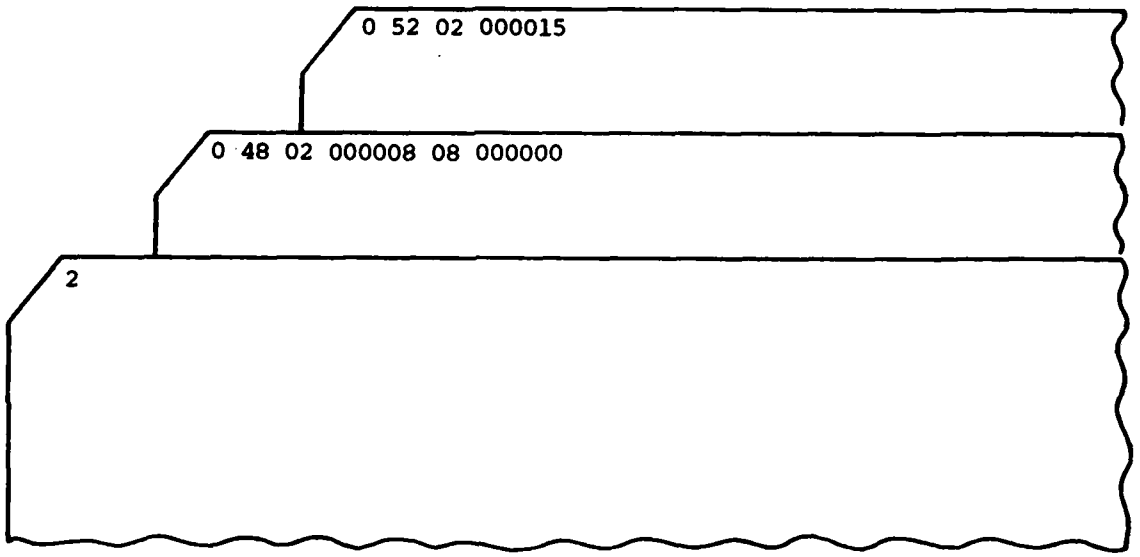


Figure 3-3. O&M COST DATA

One special feature should be noted. It is anticipated that additional RCAGs would not cause the average cost of a sector to increase as it did with the original system. The original factor for sector cost increases is therefore set to zero by using category 08.

3.4 TRANSITION DATA

Eight cards are required to implement the modernization program. These are illustrated in Figure 3-4.

It is assumed that the O&M benefits due to RCAG remote maintenance will begin in 1981. During 1981, 65 percent of the new facilities will become operational under the reduced O&M rates; in 1982, the new cost will apply to 100 percent of the RCAGs. Old RCAGs will be decommissioned at a complementary rate, i.e., 35 percent will be operational in 1981 and none in 1982. It should be noted, however, that these facilities may be decommissioned at a

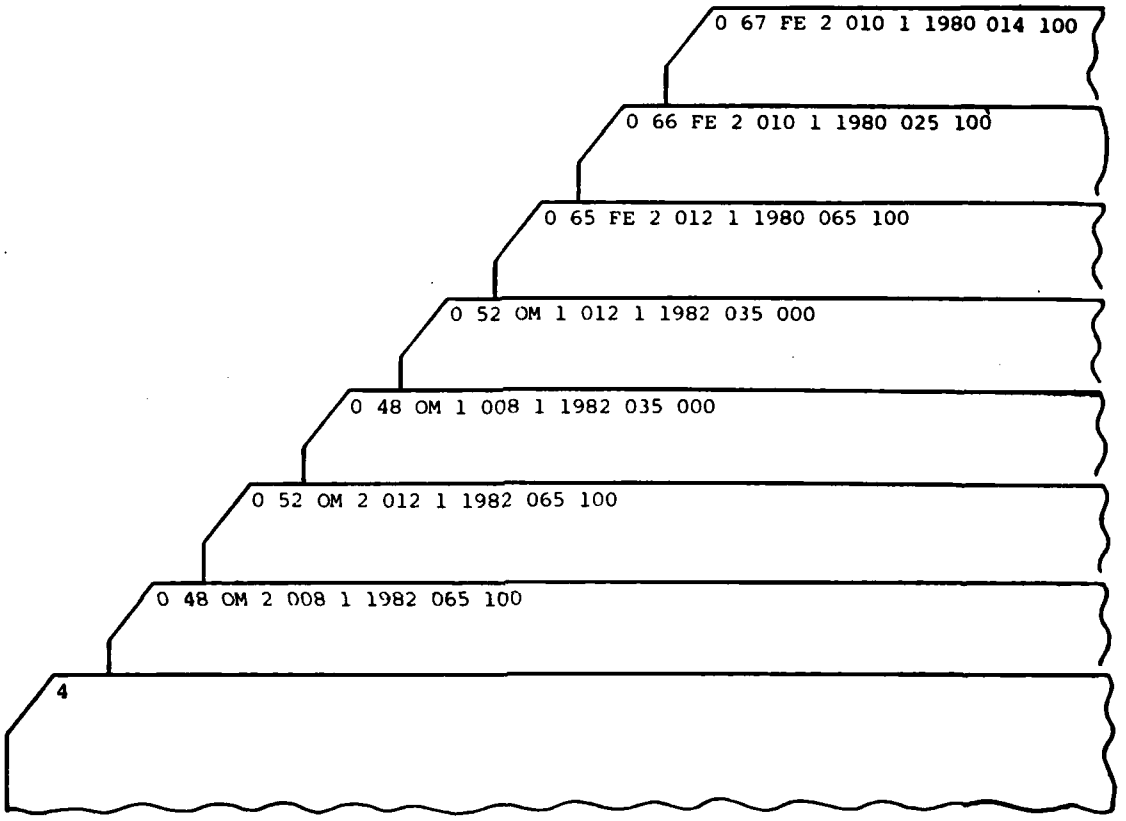


Figure 3-4. TRANSITION DATA

slower rate when redundancy is desirable. The RTRs (facility type 52) are activated with the same percentages used for RCAGs.

All new facilities and equipment will be purchased over a two-year period beginning in 1979. Enough solid-state radios will be purchased in 1979 to replace 65 percent of the vacuum-tube radios. (The model automatically uses new F&E costs for all additional radios required as a result of growth). One-hundred percent of the old radios will be replaced in the following year. It should be noted that the percentages and years used in the F&E replacement program are independent of O&M transition percentages and years. In this particular scenario, the O&M benefits begin one year after the replacement.

Twenty percent of the computers (facility type 66) will be purchased in 1979, and the remainder in the following year. The remote-maintenance monitors will be purchased in two installments also, 14 percent in 1979 and the remainder in 1980.

3.5 USER-ASSIGNED COSTS

Development and management costs during the implementation period are estimated at $75,000 per year in constant dollars. Accordingly, these costs are entered as user-assigned costs, as shown in Figure 3-5.

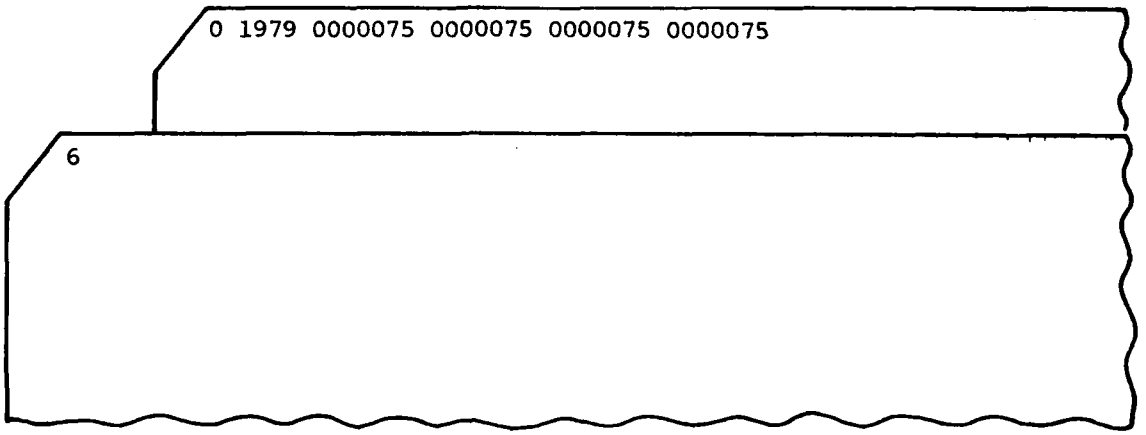


Figure 3-5. USER ASSIGNED COSTS

3.6 INFLATION AND GROWTH PARAMETERS

Figure 3-6 shows the inflation and automation cards for this run. The first three are required. The 71 card sets the long-term inflation rates at 8 percent for F&E, 8 percent for O&M, 5 percent for circuits, and 18 percent for the inflation-adjusted discount rate. Since current rates are somewhat higher, the first few years are modified by using the 73, 74, 75, and 76 cards. The parameters on the 72 card are unspecified, which will result in nominal values for growth and automation factors. The 77 card is used to set all communications percentages at 100 percent. By doing so, the user can look at the total cost picture rather than just allocated communications cost.

3.7 CIRCUIT PARAMETERS

The scenario as described here does not affect the leased circuit network. It is advisable nevertheless to specify a circuit group to be used in the calculations. This is done with two type 8 cards, as shown in Figure 3-7.

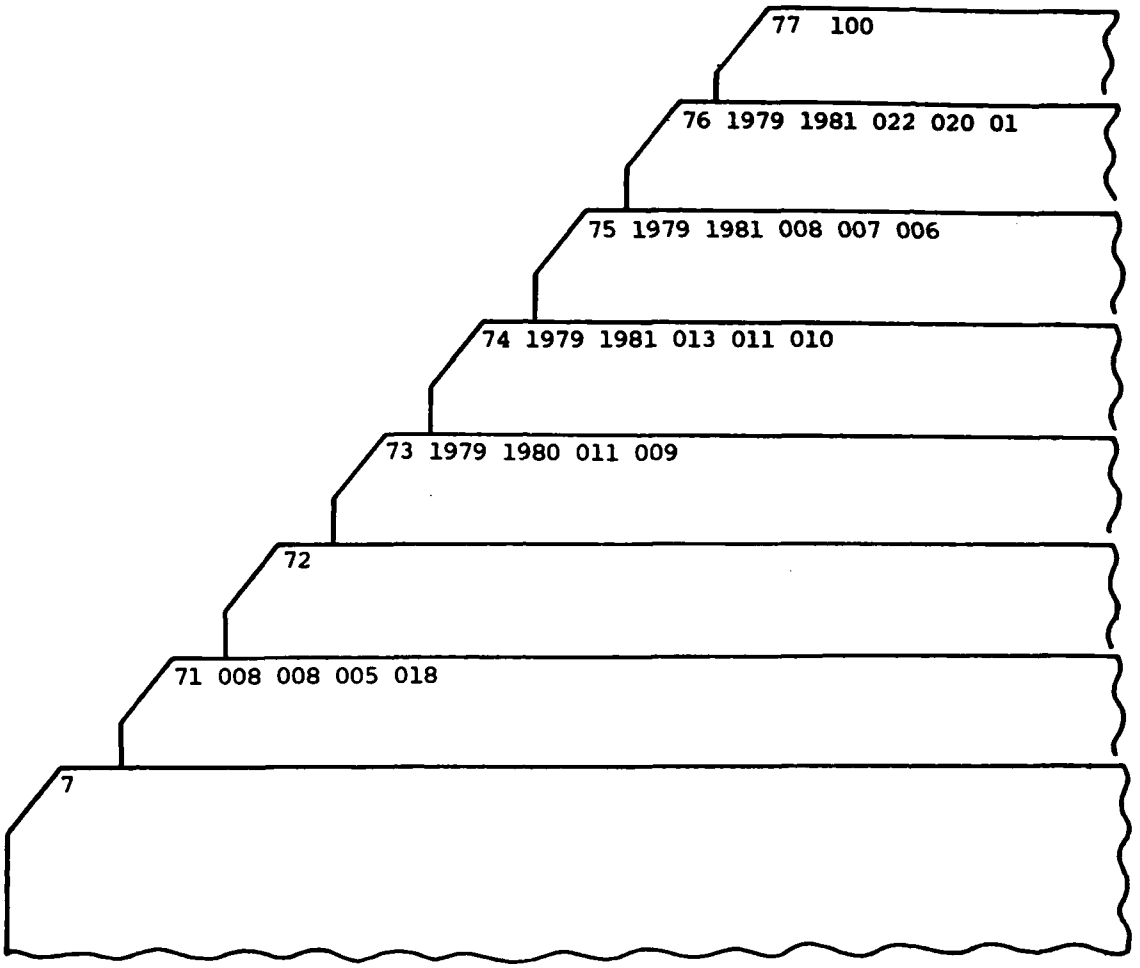


Figure 3-6. INFLATION FACTORS

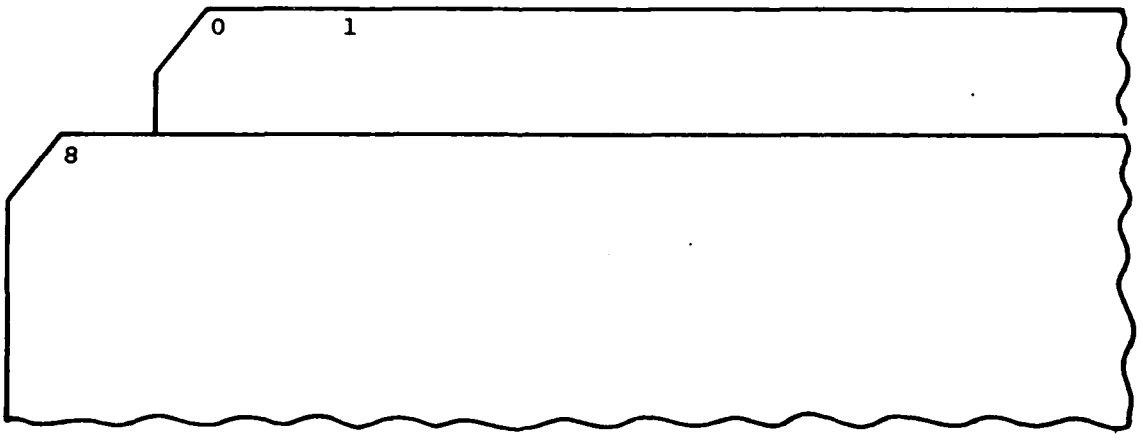


Figure 3-7. CIRCUIT PARAMETERS

3.8 ANALYSIS PERIOD

Three Type 9 cards are required for each run. These are illustrated in Figure 3-8. The period of interest specified on the second card is from 1980 through 1990. Three reports have been requested in the output listing: the detailed cost summary (Type 1), the short cost summary (Type 2), and the operational units required each year (Type 6). The third card indicates that the input phase is over and calculations should begin.

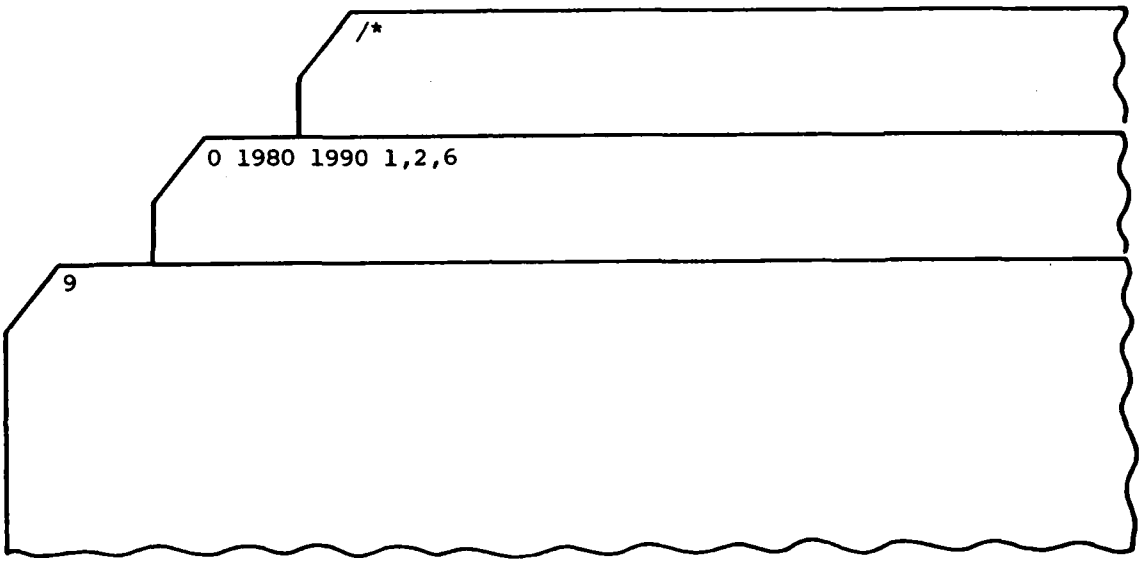


Figure 3-8. ANALYSIS PERIOD

APPENDIX A

FACILITIES AND EQUIPMENT COST ALLOCATIONS

FACILITIES AND EQUIPMENT									
Facility	Estimated 1978 Cost Per Facility * (Thousands of Dollars)	Cost Increases (Thousands of Dollars)					Esti-mated Percent COMM	Number of Facilities (1979)
		Per Sector	Per Center	Per ATCT	Per ASR	Per FSS		
1. ADCOC	0.0	0.0	0.0	0.0	0.0	0.0	1.00	11.0
2. AID	15.0	0.0	0.0	0.0	0.0	0.0	1.00	8.0
3. ARSR	3298.0	0.0	0.0	0.0	0.0	0.0	0.25	102.0
4. ARTCC	20599.0	100.0	0.0	0.0	0.0	0.0	0.60	23.0
5. ARTS	989.0	0.0	0.0	0.0	0.0	0.0	0.60	93.0
6. ASR	975.0	0.0	0.0	0.0	0.0	0.0	0.25	181.0
7. ATCT	620.0	0.0	0.0	0.0	0.0	0.0	0.85	428.0
8. BDIS	0.0	0.0	0.0	0.0	0.0	0.0	1.00	2.0
9. BUEC	80.0	0.0	0.0	0.0	0.0	0.0	1.00	204.0
10. CCC	11345.0	0.0	0.0	0.0	0.0	0.0	0.25	20.0
11. CD	201.0	0.0	0.0	0.0	0.0	0.0	1.00	107.0
12. CDC	0.0	0.0	0.0	0.0	0.0	0.0	0.80	15.0
13. CERAP	0.0	0.0	0.0	0.0	0.0	0.0	0.60	3.0
14. CKT	76.0	0.0	0.0	0.0	0.0	0.0	1.00	5.0
15. CMLT	70.0	0.0	0.0	0.0	0.0	0.0	1.00	13.0
16. COMCO	42.0	0.0	0.0	0.0	0.0	0.0	1.00	18.0
17. CST	1039.0	0.0	0.0	0.0	0.0	0.0	0.85	5.0
18. CTRB	1664.0	0.0	0.0	0.0	0.0	0.0	0.60	25.0
19. DCC	0.0	0.0	0.0	0.0	0.0	0.0	0.60	5.0
20. DF	54.0	0.0	0.0	0.0	0.0	0.0	1.00	205.0
21. EDPS	49372.0	0.0	0.0	0.0	0.0	0.0	0.25	1.0
22. FAC	22.0	0.0	0.0	0.0	0.0	0.0	0.03	21.0
23. FDEP	30.0	5.0	150.0	10.0	10.0	0.0	1.00	230.0
24. FM	18.0	0.0	0.0	0.0	0.0	0.0	0.25	36.0
25. FSS	116.0	0.0	0.0	0.0	0.0	0.0	0.85	318.0
26. GS	120.0	0.0	0.0	0.0	0.0	0.0	0.25	599.0
27. H	699.0	0.0	0.0	0.0	0.0	0.0	0.25	207.0
28. HH	130.0	0.0	0.0	0.0	0.0	0.0	0.25	9.0
29. IATSC	3403.0	0.0	0.0	0.0	0.0	0.0	1.00	1.0
30. IFSR	1203.0	0.0	0.0	0.0	0.0	0.0	1.00	6.0
31. IFSS	2405.0	0.0	0.0	0.0	0.0	0.0	1.00	6.0
32. IFST	794.0	0.0	0.0	0.0	0.0	0.0	0.25	9.0
33. IM	11.0	0.0	0.0	0.0	0.0	0.0	1.00	65.0
34. LCOT	50.0	0.0	0.0	0.0	0.0	0.0	1.00	84.0
35. LDA	17.0	0.0	0.0	0.0	0.0	0.0	0.25	10.0
36. LMM	28.0	0.0	0.0	0.0	0.0	0.0	0.25	18.0
37. LNKR	50.0	0.0	0.0	0.0	0.0	0.0	1.00	8.0
38. LOC	186.0	0.0	0.0	0.0	0.0	0.0	0.25	667.0
39. LOM	28.0	0.0	0.0	0.0	0.0	0.0	0.25	360.0
40. LRCO	18.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0
41. MM	18.0	0.0	0.0	0.0	0.0	0.0	0.25	577.0
42. OAW	30.0	0.0	0.0	0.0	0.0	0.0	1.00	23.0
43. OM	18.0	0.0	0.0	0.0	0.0	0.0	0.25	612.0

(continued)

FACILITIES AND EQUIPMENT (continued)									
Facility	Estimated 1978 Cost Per Facility* (Thousands of Dollars)	Cost Increases (Thousands of Dollars)					Esti-mated Percent COMM	Number of Facilities (1979)
		Per Sector	Per Center	Per ARCT	Per ASR	Per FSS		
44. ORES	241.0	0.0	0.0	0.0	0.0	0.0	1.00	1.0
45. PAR	1189.0	0.0	0.0	0.0	0.0	0.0	0.25	8.0
46. RAPCO	182.0	0.0	0.0	0.0	0.0	0.0	0.85	6.0
47. RBDE	151.0	0.0	0.0	0.0	0.0	0.0	0.25	101.0
48. RCAG	244.0	20.0	0.0	0.0	0.0	0.0	1.00	559.0
49. RCO	239.0	0.0	0.0	0.0	0.0	0.0	1.00	904.0
50. PMLR	166.0	0.0	0.0	0.0	0.0	0.0	1.00	518.0
51. RMLT	163.0	0.0	0.0	0.0	0.0	0.0	1.00	213.0
52. RTR	132.0	0.0	0.0	0.0	0.0	0.0	1.00	791.0
53. SFO	41.0	0.0	0.0	0.0	0.0	0.0	1.00	128.0
54. SSO	76.0	0.0	0.0	0.0	0.0	0.0	1.00	3.0
55. TELEX	151.0	0.0	0.0	0.0	0.0	0.0	1.00	5.0
56. TOWB	142.0	0.0	0.0	0.0	0.0	0.0	0.60	303.0
57. TRACO	999.0	0.0	0.0	0.0	0.0	0.0	0.60	40.0
58. TRCAB	749.0	0.0	0.0	0.0	0.0	0.0	0.60	36.0
59. TROPO	613.0	0.0	0.0	0.0	0.0	0.0	1.00	3.0
60. TTS	0.0	0.0	0.0	0.0	0.0	0.0	1.00	1.0
61. TTY	0.0	0.0	0.0	0.0	0.0	0.0	1.00	398.0
62. VOR	374.0	0.0	0.0	0.0	0.0	0.0	0.25	931.0
63. VOT	12.0	0.0	0.0	0.0	0.0	0.0	0.25	66.0
64. WMSC	7551.0	0.0	0.0	0.0	0.0	0.0	1.00	1.0

*Model will automatically update these costs for all future years according to the inflation rate specified in the scenario.

APPENDIX B

OPERATIONS AND MAINTENANCE COST ALLOCATIONS

Source: Airways Facilities Maintenance Cost Listing, produced by Transportation Systems Center Computer, Cambridge, Massachusetts.

OPERATIONS AND MAINTENANCE								
Facility		Estimated 1978 Cost Per Facility* (Thousands of Dollars)	Cost Increases (Thousands of Dollars)					Estimated Percent COMM
			Per Sector	Per Center	Per ATCT	Per ASR	Per FSS	
1.	ADCOC	127.0	0.0	0.0	0.0	0.0	0.0	0.09
2.	AID	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.	ARSR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.	ARTCC	457.0	5.0	405.0	0.0	0.0	0.0	0.74
5.	ARTS	211.0	0.0	0.0	0.0	30.0	0.0	0.14
6.	ASR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.	ATCT	52.0	0.0	0.0	27.0	0.0	0.0	0.51
8.	BDIS	54.0	0.0	0.0	0.0	0.0	0.0	1.00
9.	BUEC	26.0	0.0	0.0	0.0	0.0	0.0	1.00
10.	CCC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.	CD	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.	CDC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.	CERAP	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.	CKT	22.0	0.0	0.0	0.0	0.0	0.0	1.00
15.	CMLT	30.0	0.0	0.0	0.0	0;0	0.0	1.00
16.	COMCO	99.0	0.0	0.0	0.0	0.0	0.0	0.98
17.	CST	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.	CTRB	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19.	DCC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20.	DF	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21.	EDPS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.	FAC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23.	FDEP	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24.	FM	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25.	FSS	63.0	0.0	0.0	0.0	0.0	63.0	0.81
26.	GS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27.	H	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28.	HH	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29.	IATSC	488.0	0.0	0.0	0.0	0.0	0.0	1.00
30.	IFSR	98.0	0.0	0.0	0.0	0.0	0.0	1.00
31.	IFSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32.	IFST	249.0	0.0	0.0	0.0	0.0	0.0	0.32
33.	IM	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34.	LCOT	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35.	LDA	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36.	LMM	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37.	LNKR	5.0	0.0	0.0	0.0	0.0	0.0	1.00
38.	LOC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39.	LOM	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40.	LRCO	23.0	0.0	0.0	0.0	23.0	0.0	1.00

(continued)

OPERATIONS AND MAINTENANCE (continued)							
Facility	Estimated 1978 Cost Per Facility* (Thousands of Dollars	Cost Increases (Thousands of Dollars)					Esti-mated Percent COMM
		Per Sector	Per Center	Per ATCT	Per ASR	Per FSS	
41. MM	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42. OAW	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43. OM	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44. ORES	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45. PAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46. RAPCO	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47. RBDE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
48. RCAG	36.0	0.0	0.0	0.0	0.0	0.0	1.00
49. RCO	31.0	0.0	0.0	0.0	0.0	0.0	1.00
50. RMLR	32.0	0.0	0.0	0.0	0.0	0.0	1.00
51. RMLT	37.0	0.0	0.0	0.0	0.0	0.0	1.00
52. RTR	20.0	0.0	0.0	20.0	20.0	20.0	1.00
53. SFO	11.0	0.0	0.0	0.0	0.0	0.0	1.00
54. SSO	7.0	0.0	0.0	0.0	0.0	0.0	1.00
55. TELEX	100.0	0.0	0.0	0.0	0.0	0.0	1.00
56. TOWB	0.0	0.0	0.0	0.0	0.0	0.0	0.0
57. TRACO	45.0	0.0	0.0	0.0	0.0	0.0	0.21
58. TRCAB	49.0	0.0	0.0	0.0	0.0	0.0	0.17
59. TROPO	49.0	0.0	0.0	0.0	0.0	0.0	1.00
60. TTS	218.0	0.0	0.0	0.0	0.0	0.0	1.00
61. TTY	14.0	0.0	14.0	14.0	14.0	14.0	1.00
62. VOR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63. VOT	0.0	0.0	0.0	0.0	0.0	0.0	0.0
64. WMSC	259.0	0.0	0.0	0.0	0.0	0.0	1.00

*Model will automatically update these costs for all future years according to the inflation rate specified in the scenario.

APPENDIX C

FAA COMMUNICATIONS MODEL REPORTS

1. Detailed Cost Summary - Report Type 1

This is a detailed output report showing each cost category, inflation effects, totals, discounted total, and cumulative discounted total:

Col 1 - year

Col 2 - total F&E expenditure for the year in current dollars

Col 3 - total O&M expenditure for the year, in current dollars

Col 4 - total cost for leased circuits including channel terminations, in current dollars

Col 5 - total cost for leased communications equipment, in current dollars

Col 6 - user assigned costs in current dollars

Col 7 - total of preceding annual costs

Col 8 - deflated and discounted value of total annual cost

Col 9 - cumulative discounted value

COSTS BY CATEGORY-ALL AMOUNTS IN MILLIONS OF DOLLARS

YEAR	FACILITIES AND EQUIPMENT	OPERATIONS AND MAINTENANCE	CIRCUITS	LEASED EQUIPMENT	USER ASSIGNED	TOTAL	NET PRESENT VALUE	CUMULATIVE NET PRESENT VALUE
1980	$ 46.4	$ 254.1	$ 22.1	$ 71.3	$ 0.1	$ 393.9	$ 328.3	$ 328.3
1981	$ 60.4	$ 281.3	$ 23.6	$ 75.8	$ 0.1	$ 441.2	$ 334.3	$ 662.5
1982	$ 15.2	$ 284.9	$ 24.9	$ 79.9	$ 0.1	$ 405.0	$ 260.0	$ 922.6
1983	$ 16.6	$ 297.3	$ 26.3	$ 84.2	$ 0.0	$ 424.4	$ 230.9	$ 1153.5
1984	$ 18.1	$ 322.5	$ 27.8	$ 88.7	$ 0.0	$ 457.2	$ 210.8	$ 1364.3
1985	$ 19.8	$ 349.9	$ 29.3	$ 93.5	$ 0.0	$ 492.5	$ 192.4	$ 1556.7
1986	$ 21.7	$ 379.5	$ 31.0	$ 98.5	$ 0.0	$ 530.7	$ 175.7	$ 1732.5
1987	$ 23.8	$ 411.0	$ 32.7	$ 103.7	$ 0.0	$ 572.0	$ 160.5	$ 1893.0
1988	$ 26.1	$ 446.8	$ 34.5	$ 109.3	$ 0.0	$ 616.7	$ 146.7	$ 2039.7
1989	$ 28.7	$ 484.8	$ 36.4	$ 115.1	$ 0.0	$ 665.0	$ 134.0	$ 2173.7
1990	$ 41.7	$ 526.0	$ 38.4	$ 121.2	$ 0.0	$ 727.4	$ 124.2	$ 2297.9

2. Short Cost Summary - Report Type 2

This is an abbreviated version of the detailed cost summary:

Col 1 - year

Col 2 - total annual costs, in current dollars

Col 3 - deflated and discounted annual total

YEAR	TOTAL	NET PRESENT VALUE (MILLIONS)
1980	$ 393.9268	$ 328.2722
1981	$ 441.2441	$ 334.2759
1982	$ 405.0447	$ 260.0442
1983	$ 424.4280	$ 230.9226
1984	$ 457.1541	$ 210.7867
1985	$ 492.5100	$ 192.4482
1986	$ 530.7188	$ 175.7444
1987	$ 572.0188	$ 160.5259
1988	$ 616.6738	$ 146.6590
1989	$ 664.9683	$ 134.0208
1990	$ 727.3547	$ 124.2326

3. Facilities and Equipment Matrix - Report Type 3

This report lists all of the F&E parameters used in the model:

Col 1 - facility type
Col 2 - total cost of an old facility
Col 3 - total cost of a new facility
Col 4 - old facility cost increase per sector
Col 5 - old facility cost increase per center
Col 6 - old facility cost increase per tower
Col 7 - old facility cost increase per terminal radar
Col 8 - old facility cost increase per FSS
Col 9 - new facility cost increase per sector
Col 10 - new facility cost increase per center
Col 11 - new facility cost increase per tower
Col 12 - new facility cost increase per terminal radar
Col 13 - new facility cost increase per FSS
Col 14 - percent of cost due to communications
Col 15 - total number of facilities

FACILITIES AND EQUIPMENT MATRIX

FACILITY	OLD COST	NEW COST	OLD FACILITY COST INCREASE PER SECTOR	PER CENTER	PER TOWER	PER ASR	PER FSS	NEW FACILITY COST INCREASE PER SECTOR	PER CENTER	PER TOWER	PER ASR	PER FSS	PCT COMM	NO FACILITY
ADCO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	12.
AID	15.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	10.
ARSR	3298.0	3298.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	102.
ARTC	20599.0	20599.0	100.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	1.00	23.
ARTS	989.0	989.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	98.
ASR	975.0	975.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	159.
ATCT	620.0	620.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	428.
BDIS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	2.
BUEC	80.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	239.
CCC	11345.0	11345.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	20.
CD	201.0	201.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	102.
CDC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	15.
CERA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	3.
CKT	76.0	76.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	5.
CMBT	70.0	70.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	13.
COMC	42.0	42.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	18.
CST	1039.0	1039.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	5.
CTRB	1664.0	1664.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	25.
DCC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	5.
DF	54.0	54.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	205.
EDPS	49372.0	49372.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	1.
FAC	22.0	22.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	21.
FDEP	30.0	30.0	5.0	150.0	10.0	10.0	0.0	5.0	150.0	10.0	10.0	0.0	1.00	222.
FK	18.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	36.
FSS	116.0	116.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	318.
GS	120.0	120.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	600.
H	699.0	699.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	209.
HH	130.0	130.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	9.
IATS	3403.0	3403.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	1.
IFSR	1203.0	1203.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	6.
IFSS	2405.0	2405.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	6.
IFST	794.0	794.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	9.
IM	11.0	11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	57.
LCOT	50.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	84.
LDA	17.0	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	10.
LMM	28.0	28.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	17.
LNKR	50.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	8.
LOC	186.0	186.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	669.
LOM	28.0	28.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	316.
LRCO	18.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	581.
MM	18.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	577.
OAW	30.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	22.
OM	18.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	615.
ORES	241.0	241.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	1.
PAR	1189.0	1189.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	8.
RAPC	182.0	182.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	6.
RBDE	151.0	151.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	101.
RCAG	244.0	244.0	20.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0	1.00	550.
RCO	239.0	239.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	1.00	909.
RMLR	166.0	166.0	0.0				0.0	0.0				0.0	1.00	
RMLT	163.0	163.0	0.0				0.0	0.0				0.0	1.00	
	132.0	132.0												
	41.0	41.0												

4. Operations and Maintenance Matrix - Report Type 4

This report gives all of the O&M parameters used in the model:

Col 1 - facility type

Col 2 - maintenance cost of old facility

Col 3 - maintenance cost of new facility

Col 4 - old maintenance cost increase per sector

Col 5 - old maintenance cost increase per center

Col 6 - old maintenance cost increase per tower

Col 7 - old maintenance cost increase per terminal radar

Col 8 - old maintenance cost increase per FSS

Col 9 - new maintenance cost increase per sector

Col 10 - new maintenance cost increase per center

Col 11 - new maintenance cost increase per tower

Col 12 - new maintenance cost increase per terminal radar

Col 13 - new maintenance cost increase per FSS

Col 14 - percent of cost due to communications

Col 15 - total number of facilities

OPERATIONS & MAINTENANCE MATRIX

FACILITY	OLD COST	NEW COST	OLD FACILITY COST INCREASE PER SECTOR	PER CENTER	PER TOWER	PER ASR	PER FSS	NEW FACILITY COST INCREASE PER SECTOR	PER CENTER	PER TOWER	PER ASR	PER FSS	PCT COMM	NO FACILITY
ADCO	127.0	127.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	12.
AID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	10.
ARSR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	102.
ARTC	457.0	457.0	5.0	405.0	0.0	0.0	0.0	5.0	405.0	0.0	0.0	0.0	1.00	23.
ARTS	211.0	211.0	0.0	0.0	0.0	30.0	0.0	0.0	0.0	0.0	30.0	0.0	1.00	98.
ASR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	159.
ATCT	52.0	52.0	0.0	0.0	27.0	0.0	0.0	0.0	0.0	27.0	0.0	0.0	1.00	428.
BDIS	54.0	54.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	2.
BUEC	26.0	26.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	239.
CCC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	20.
CG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	102.
CDC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	15.
CERA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	3.
CKT	22.0	22.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	5.
CMBT	30.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	13.
COMC	99.0	99.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	18.
CST	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	5.
CTRB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	25.
DCC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	5.
DF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	205.
EDPS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	1.
FAC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	21.
FDEP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	222.
FM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	36.
FSS	63.0	63.0	0.0	0.0	0.0	0.0	63.0	0.0	0.0	0.0	0.0	63.0	1.00	318.
GS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	600.
H	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	209.
HH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	9.
IATS	488.0	488.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	1.
IFSR	98.0	98.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	6.
IFSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	6.
IFST	249.0	249.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	9.
IM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	57.
LCOT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	84.
LDA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	10.
LMM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	17.
LNKR	5.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	8.
LOC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	669.
LOM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	316.
LRCO	23.0	23.0	0.0	0.0	0.0	23.0	0.0	0.0	0.0	0.0	23.0	0.0	1.00	581.
MM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	577.
OAW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	22.
OM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	615.
ORES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	1.
PAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	8.
RAPC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	6.
RBDE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	101.
RCAG	36.0	8.0	25.0	0.0	[illegible]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	550.
RCO	31.0	31.0	0.0				0.0	0.0	0.0	0.0		[illegible]	1.00	909.
[illegible]	32.0	32.0	[illegible]				[illegible]	0.0	0.0	0			1.00	515.
	[illegible]	[illegible]						0.0	0.0				[illegible]	204

5. Tariff Array - Report Type 5

The average cost-per-mile and the cost of channel terminations for both ends of a circuit are listed in the tariff array for each tariff defined in the program or by the user. The rates are listed in order, one through nine.

TARIFF MATRIX

1	COST = $ 0.50	SERVICE = $ 86.60
2	COST = $ 1.75	SERVICE = $156.90
3	COST = $ 0.0	SERVICE = $ 0.0
4	COST = $ 0.0	SERVICE = $ 0.0
5	COST = $ 0.0	SERVICE = $ 0.0
6	COST = $ 0.0	SERVICE = $ 0.0
7	COST = $ 0.0	SERVICE = $ 0.0
8	COST = $ 0.0	SERVICE = $ 0.0
9	COST = $ 0.0	SERVICE = $ 0.0

6. Operational Units Matrix - Report Type 6

There are 15 entries in this matrix. The rows represent the various operational units while the columns contain past year, present year, and baseline quantities for each. Figure C-1 shows the arrangement of this table.

Type of Units	Number of Units in Baseline System (1979)	Number of Units Required in Current Year	Number of Units Required in Previous Year
Sectors	A	B	C
Centers	D	E	F
Towers	G	H	I
Terminal Radars	J	K	L
FSS	M	N	O

Figure C-1. OPERATIONAL UNITS MATRIX

OPERATION MATRIX

723.0000	737.0642	723.0000
23.0000	23.0000	23.0000
428.0000	428.0000	428.0000
159.0000	161.2459	159.0000
318.0000	318.0000	318.0000

7. Switch Array (circuit parameters) - Report Type 1

The switch array is composed of nine columns as shown below. Columns 3 through 8 are used for computing shared circuit requirements. The rows of the switch array are documented in Section 2.8 of this report.

Col 1 - zero if circuit is not switched; one otherwise

Col 2 - tariff used to price this circuit

Col 3 - average circuit length

Col 4 - average number of circuits required per facility

Col 5 - total length

Col 6 - total quantity required

Col 7 - busy hour average utilization per circuit

Col 8 - total utilization of all circuits

Col 9 - Equipment cost per circuit

Col 10 - Required grade of service

SWITCH ARRAY

0.0	1.00	141.92	1487.00	211035.00	1487.00	0.08	118.96	122.27	0.01
0.0	1.00	74.90	0.41	13143.45	175.48	0.05	8.77	119.05	0.01
0.0	1.00	257.30	0.32	26182.82	101.76	0.05	5.09	261.21	0.01
0.0	1.00	149.28	1.41	90087.44	603.48	0.10	60.35	123.36	0.01
0.0	1.00	435.42	11.91	119274.50	273.93	0.10	27.39	114.49	0.01
0.0	1.00	43.54	4.44	61859.22	1420.74	0.12	170.49	65.18	0.01
0.0	1.00	456.96	947.00	432741.06	947.00	0.13	123.11	254.33	0.01
0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
0.0	1.00	542.59	0.09	15528.91	28.62	0.85	24.33	271.75	0.01
0.0	1.00	112.96	0.56	27074.25	239.68	0.30	71.90	117.20	0.01
0.0	1.00	500.36	4.13	47529.17	94.99	0.30	28.50	124.08	0.01
0.0	1.00	88.11	128.00	11278.08	128.00	0.08	10.24	91.80	0.01
0.0	1.00	168.18	3.48	326627.00	1942.13	0.30	582.64	169.54	0.01
0.0	1.00	[illegible]3.85	3.15	63958.52	1001.70	0.20	200.34	95.19	0.01
0.0	1.00	31.92	1.55	21175.71	663.40	0.30	199.02	75.59	0.01
0.0	1.00	192.68	3.65	16175.48	83.95	0.08	6.72	106.55	0.01
0.0	1.00	107.10	311.00	33308.09	311.00	0.17	52.87	59.22	0.01
0.0	-1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
0.0	-1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
0.0	-1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
0.0	-1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
0.0	-1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
0.0	-1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
0.0	-1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
0.0	-1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
0.0	-1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
0.0	-1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
0.0	-1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
0.0	-1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01
0.0	-1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01

8. Main Array - Report Type 8

The Main Array consists of 95 facility types; 23 parameters are listed for each facility type. These parameters are described as though there are 24 column headings; paper width limitations require them to be printed as two rows:

Col 1 - facility type

Col 2 - facility requirements in current year

Col 3 - increase in number of facilities per additional sector (current year)

Col 4 - Increase in number of facilities per additional center (current year)

Col 5 - Increase in number of facilities per additional tower (current year)

Col 6 - increase in number of facilities per additional terminal radar (current year)

Col 7 - increase in number of facilities per additional FSS (current year)

Col 8 - facility requirements for previous year

Col 9 - increase in number of facilities per additional sector (previous year)

Col 10 - increase in number of facilities per additional center (previous year)

Col 11 - increase in number of facilities per additional tower (previous year)

Col 12 - increase in number of facilities per additional terminal radar (previous year)

Col 13 - increase in number of facilities per additional FSS (previous year)

Col 14 - transition year (last two digits) - nominally set to 100 unless there is a transition

Col 15 - number of facilities in baseline system (1978)

Col 16 - number of facilities required in current year

Col 17 - number of facilities required in previous year

Col 18 - number of facilities required before transition

Col 19 - number of sectors before transition

Col 20 - number of centers before transition

Col 21 - number of towers before transition

Col 22 - number of terminal radars before transition

Col 23 - number of FSSs before transition

Col 24 - year of transition (nominally set to 100 unless there is a transition

MAIN ARRAY

1	ADCO	12.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		110.00	12.00	12.00	12.00	12.00	0.0	0.0	0.0	0.0	0.0	110.00	
2	AID	12.00	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		110.00	10.00	12.00	10.00	10.00	0.0	0.0	0.0	0.0	0.0	110.00	
3	ARSR	102.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		110.00	102.00	102.00	102.00	102.00	0.0	0.0	0.0	0.0	0.0	110.00	
4	ARTC	23.00	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		110.00	23.00	23.00	23.00	23.00	0.0	0.0	0.0	0.0	0.0	110.00	
5	ARTS	101.59	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		110.00	98.00	101.59	100.25	98.00	0.0	0.0	0.0	0.0	0.0	110.00	
6	ASR	162.59	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		110.00	159.00	162.59	161.25	159.00	0.0	0.0	0.0	0.0	0.0	110.00	
7	ATCT	430.00	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		110.00	428.00	430.00	428.00	428.00	0.0	0.0	0.0	0.0	0.0	110.00	
8	BDIS	2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		110.00	2.00	2.00	2.00	2.00	0.0	0.0	0.0	0.0	0.0	110.00	
9	BUEC	239.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		110.00	239.00	239.00	239.00	239.00	0.0	0.0	0.0	0.0	0.0	110.00	
10	CCC	20.00	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		110.00	20.00	20.00	20.00	20.00	0.0	0.0	0.0	0.0	0.0	110.00	
11	CD	102.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		110.00	102.00	102.00	102.00	102.00	0.0	0.0	0.0	0.0	0.0	110.00	
12	CDC	15.00	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		110.00	15.00	15.00	15.00	15.00	0.0	0.0	0.0	0.0	0.0	110.00	
13	CERA	3.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		110.00	3.00	3.00	3.00	3.00	0.0	0.0	0.0	0.0	0.0	110.00	
14	CKT	5.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		110.00	5.00	5.00	5.00	5.00	0.0	0.0	0.0	0.0	0.0	110.00	
15	CMBT	13.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		110.00	13.00	13.00	13.00	13.00	0.0	0.0	0.0	0.0	0.0	110.00	
16	COMC	18.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		110.00	18.00	18.00	18.00	18.00	0.0	0.0	0.0	0.0	0.0	110.00	
17	CST	5.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		110.00	5.00	5.00	5.00	5.00	0.0	0.0	0.0	0.0	0.0	110.00	
18	CTRB	25.00	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		110.00	25.00	25.00		25.00	0.0	0.0	0.0	0.0	0.0	110.00	
		5.00					0.0	0.0				0.0	
								0.0					

9. F&E Changes

All changes to F&E costs are summarized in the output listing. The columns are as follows:

Col 1 - facility type code

Col 2 - type of change

Col 3 - original value

Col 4 - new value

Col 5 - year in which new cost becomes effective (e.g., "96" would signify 1996; 110 would signify 2010)

10. O&M Changes

All changes to O&M costs are also summarized in the output listing. The columns are the same as those previously used in the F&E listing.

F AND E CHANGES

65	BASIC COST OF NEW FACILITY	0.0	28.00	110.
65	PERCENT OF COST DUE TO COMMUNICATIONS	1.00	1.00	110.
65	NUMBER OF FACILITIES REQUIRED IN SYSTEM	0.0	1287.00	110.
66	BASIC COST OF NEW FACILITY	0.0	188.00	110.
66	PERCENT OF COST DUE TO COMMUNICATIONS	1.00	0.33	110.
66	NUMBER OF FACILITIES REQUIRED IN SYSTEM	0.0	25.00	110.
67	BASIC COST OF NEW FACILITY	0.0	40.00	110.
67	PERCENT OF COST DUE TO COMMUNICATIONS	1.00	1.00	110.
67	NUMBER OF FACILITIES REQUIRED IN SYSTEM	0.0	565.00	110.

O AND M CHANGES

RCAG	MAINTENANCE COST OF NEW FACILITY	36.00	8.00	110.
RCAG	NEW MAINTENANCE COST INCREASE PER SECTOR	25.00	0.0	110.
RTR	MAINTENANCE COST OF NEW FACILITY	20.00	15.00	110.

APPENDIX D

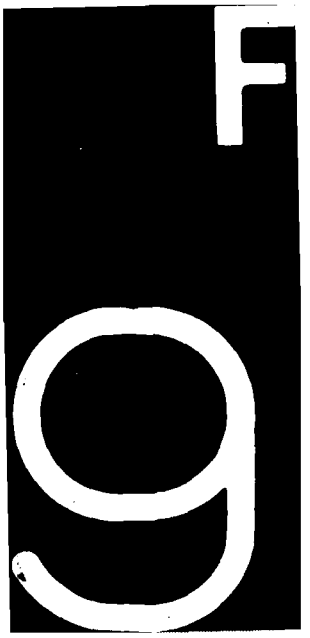
FACILITY CATEGORY DESCRIPTIONS

Table D-1 lists facility Alpha codes and briefly describes the facilities. These facility categories are fully defined in Appendix 1 of Airway Facility Sector Level Staffing Standard System, FAA Order 1380.40, issued 8 December 1976.

FACILITY ALPHA CODES AND DESCRIPTIONS	
Alpha Code	Description
ADCOC	Air Defense Command Operation Control
AID	Airport Information Desk
ARSR	Air Route Surveillance Radar -- FAA and Military
ARTCC	Air Route Traffic Control Center
ARTS	Automated Radar Terminal System
ASR	Airport Surveillance Radar -- FAA and Military
ATCT	Airport Traffic Control Tower
BDIS	Automatic Data Interchange System, Service "B"
BRITE	Bright Radar Indicator Terminal Equipment
BUEC	Backup Emergency Communications
CCC	Central Computer Complex -- IBM 9020 System
CD	Common Digitizer
CDC	Computer Display Channel
CERAP	Combined Center/RAPCO
CKT	Control Circuit Equipment
CMLT	Communications Microwave Link Terminal
COMCO	Command Communications Outlet
CST	Combined Station/Tower
CTRB	Center Building Maintenance
DCC	Display Channel Complex
EDPS	Electronic Data Processing System
FDEP	Flight Data Entry and Printout
FSS	Flight Service Station
GS	Glide Slope
H	Homing Radio Beacon
HH	Homing Radio Beacon -- High Power
IATSC	International Aeronautical Telecommunications Switching Center
IFSR	International Flight Service Receiving Station
IFSS	International Flight Service Station
IFST	International Flight Service Transmitter Station
IM	Inner Marker

(continued)

FACILITY ALPHA CODES AND DESCRIPTIONS (continued)	
Alpha Code	Description
LCOT	VHF/UHF Link Terminal
LDA	Localizer-Type Directional Aid
LMM	Compass Locator at the ILS Middle Marker
LNKR	Link Repeater
LOC	ILS Localizer
LOM	Compass Locator at the ILS Outer Marker
LRCO	Limited Remote Communication Outlet
MM	Middle Marker
OAW	Off-Airways Weather Station
OM	Outer Marker
ORES	IFSS Residual Facility
PAR	Precision Approach Radar -- FAA and Military
RBDE	Radar Bright Display Equipment
RCAG	Remote Center Air/Ground Communications Facility
RCO	Remote Communications Outlet
RMLR	Radar Microwave Link Repeater
RMLT	Radar Microwave Link Terminal
RTR	Remote Transmitter/Receiver Facility
SFO	Single Frequency Outlet
SSO	Self-Sustained Outlet
TELEX	Telephone Exchange
TOWB	Tower Building Maintenance
TRACO	Terminal Radar Approach Control
TRCAB	Terminal Radar Approach Control in Tower Cab
TROPO	Tropospheric Scatter Station
TTS	Teletype Switching Facilities
TTY	Teletypewriter Station
VOR	VHF Omnidirectional Range
VOT	VHF Omnidirectional Range Test
WMSC	Weather Message Switching Center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